



## ChemE Car Engineering Design Proposal Packet (EDP+)

### American Institute of Chemical Engineers University of Wyoming Student Chapter ChemE Car Team

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*“The word design has the same Latin origin as designate: ‘to point out or to show to others.’ If you have an idea and produce it yourself, you aren’t a designer - you’re an artist or a craftsman (not that there’s anything wrong with that). You don’t become a designer until you tell someone else about your idea so that they can do all the dirty, heavy work of producing it.”*  
- Bill Fane and David Byrnes, *AutoCAD for Dummies*

#### OVERALL CAR DESIGN STATEMENT

The ChemE Car That Cud showcases Wyoming’s dominant industries of agriculture and mining by utilizing rumen fluid from a cannulated beef cow to generate hydrogen to be used in a hydrogen fuel cell and radioactive cesium, a byproduct of uranium that is often obtained from Wyoming’s mines, to time the car’s stop. The concentration of cesium-137 source is measured using the radioactive decay of cesium shielded by aluminum. The painted aluminum chassis was obtained from a previous team at UW, and modified using plastic k’nex toys to adapt to the current power source and stopping mechanism.

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## INTRODUCTION

### Overview of the AIChE ChemE Car Competition

The American Institute of Chemical Engineers (AIChE) hosts the national ChemE Car Competition each year. For the competition, teams made up of undergraduate chemical engineering students compete by designing and constructing shoebox-sized cars powered and stopped by chemical reactions. The aim is to build a car that can carry an arbitrary payload of between 0 and 500 mL of water an arbitrary distance of between 15 and 30 m.

The chemical reactions powering the car must occur on the car during the run. In cases where this presents almost no challenge (e.g. a hydrogen fuel cell), the reagents must be produced by the team immediately prior to running the car. No open flames are allowed on cars, and internal combustion is only allowed if it follows very stringent guidelines.

Stopping mechanisms must be chemically driven. While teams are allowed to use mechanical and electronic devices to monitor reactions and control the car, direct mechanical and/or electrical timers are strictly forbidden. In any case where programmable electronics are used on a car, no user input is allowed once a contest has begun, and judges are entitled to the source code used in any electronics.

Safety is also a fundamental concern of the ChemE Car Competition coordinators, and all cars must be thoroughly assessed on their safety. Extreme temperatures, high pressures, exposed electronics, pathogenic microorganisms, and unstable (NFPA rating higher than 2) compounds are expressly forbidden. These rules are to ensure that cars can operate without endangering the general public at the convention centers where contests are typically held.

Teams can compete on a national level, but they must first qualify at a regional contest. At a contest session, teams must present a poster and documentation on their cars. Then, a payload and distance are announced, and teams have between one and three hours to prepare and calibrate their car to carry that exact amount of water that exact distance. Each car runs in sequence, and the winner is determined based on the difference between the target distance and the distance the car actually travelled. Minor prizes are typically given for categories like “most original” and “best poster,” but these vary by region. The national ChemE Car Contest hosts a yet unclaimed prize for the “Best use of a biological reaction.”

### History of The ChemE Car That Cud

Work on The ChemE Car That Cud started in Spring 2017, when Thomas Christensen II was appointed ChemE Car Team Captain of the University of Wyoming AIChE Student Chapter. The last time UW's ChemE Car team had competed was in 2014, when a catastrophic failure caused the team's disqualification. After that competition, the 2014 team abandoned the car and its components, and no substantive work was done to create a new entry for the UW AIChE Chapter until 2017. At that point, no students or paperwork remained to explain the previous car design, except for a completed AIChE safety check form booklet. Even that small help turned out to be nearly useless thanks to a giant hole burned through the center by spilled hydrogen peroxide. This left the new team to start a new design from scratch.

Based on information from posters at regional contests, the most common reactions used in ChemE Car are hydrogen fuel cells for power and an iodine clock for stopping. For UW's car, it

was determined that those reactions should be avoided to maintain originality. Instead, a design based on electrical power from a Microbial Fuel Cell (MFC) was selected due to its novelty and for eligibility for the biological reaction prize. Rumen fluid was selected as the inoculum for the MFCs due to a combination of safety, availability, and novelty. Stopping was based on radioactive decay of cesium-137 as this reaction proceeds at a very well-defined rate. Cesium-137 is also safe to use and does not require a radioactive materials license. This design was originally slated for entry into the 2018 regional ChemE Car Competition, however it was found that in an MFC setup, rumen fluid requires more power to propel it than it can generate. A new approach was required.

To maximize use of the time and research that had already occurred, and after calculations using data from the previous design demonstrated its feasibility, it was decided to switch to a rumen fluid Microbial Electrolysis Cell (MEC) setup with store-bought hydrogen fuel cells. MECs are closely related to Microbial Fuel Cells. In fact, the apparatuses used for both procedures are identical. While an MFC generates electricity, an MEC requires electrical input to generate hydrogen gas. The cesium-137 decay counter was kept as a stopping mechanism as it had no inherent design flaws unlike the rumen fluid MFC. It is this car design that became The ChemE Car That Cud. The name was chosen as a play-on-words since ruminants “chew the cud.”

The ChemE Car That Cud was entered and competed in the 2019 Rocky Mountain Regional ChemE Car Competition. The design and car passed all safety checks with no hesitations. Other difficulties were experienced, however, as some rumen fluid had been frozen in transit, and could not be heated to operating temperature in time. This resulted in less hydrogen production than expected. Also, some damage was sustained to the Geiger-Muller tube for the cesium-137 decay reaction during transportation. Overall, this resulted in the car stopping prematurely due to a lack of hydrogen rather than by monitoring the cesium decay as planned. Despite these difficulties, the car still ran and earned seventh place out of twelve teams: travelling a distance of 321 out of about 1640 cm. It was also the only biological reaction present at the contest.

The car design was successful in that biologically generated hydrogen was able to power the car on-demand. However, there is still much room for improvement. Alternatives to the current body and motor that would require less power should be considered. Improved hydrogen fuel cells that produce more power might also be an option. The overly complex myRIO control unit could be replaced with a smaller, less expensive microcontroller that outputs 5V pulses to match the relays such as an Arduino. Rumen fluid media, although tried without success during the course of these experiments, if functional would require less refrigerated rumen inoculum and reduce the heat transfer challenges.

This report was created to present the 2019 UW ChemE Car design such that future team members have a basis on which to make improvements such as the ones described above, or others they may come up with. If ChemE Car were to be abandoned again, this document should also allow any future team member with no previous experience to build and run this car. AIChE requires documentation to be submitted for entry into the ChemE Car Competition, however that documentation focuses mainly on safety procedures and dismisses nearly all information concerning design and operation. To fill that void, this document

contains detailed instructions for construction and operation, along with information describing the theory and chemistry that motivated these procedures.

## PROPULSION REACTION

### Overall Description

The hydrogen fuel cell utilizes biologically derived hydrogen to power an electric motor. Hydrogen is produced in a microbial electrolysis cell inoculated with bovine rumen fluid fed by glucose.

A voltage applied across an inoculum of bovine rumen fluid consuming glucose as a substrate allows the microorganisms to reduce aqueous protons ( $H^+$ ), producing Hydrogen gas ( $H_2$ ). This Hydrogen gas generated in batch is collected and fed to a Proton Exchange Membrane Fuel Cell (PEMFC). The PEMFC reduces atmospheric Oxygen ( $O_2$ ) by reacting  $O_2$  with the electrons generated from the oxidation of Hydrogen gas, producing water ( $H_2O$ ). The movement of electrons through an external circuit produces current to power the motor.

### Further Background and Theory

The rumen is a strictly anaerobic and largely fermentative microbial environment. One of the most produced fermentative products in the rumen is hydrogen gas. Hydrogen is exchanged between so many organisms and is important in so many metabolic pathways, that it has been called the “currency” of the rumen.<sup>1</sup> An average sheep, with a rumen size of roughly 10 gallons, is estimated to produce at least 100 L/day of hydrogen, although most of this is converted to methane.<sup>2</sup> Converting and scaling, this results in 110 mL of hydrogen being produced from 1 L of rumen fluid in an hour.

Hydrogen is a high-energy molecule, and a Proton Exchange Membrane Fuel Cell (PEMFC) can convert hydrogen gas and atmospheric oxygen into electrical power that can be used directly. The theory behind PEMFCs is well-established, and PEMFCs can be easily purchased. Horizon Mini PEM Reversible Fuel Cells from FuelCellStore (<https://www.fuelcellstore.com/horizon-mini-reversible-fuel-cell>) require 25 mL of hydrogen to power a 3 V motor for 2 min. Since rumen fluid produces more than enough hydrogen to power the motor for the car, it was decided to generate hydrogen from rumen fluid and use a PEMFC to convert that hydrogen to electrical power to propel the car.

In order to facilitate the production of hydrogen from rumen microbes outside of the rumen, a Microbial Electrolysis Cell (MEC) device was used. MECs facilitate the production of hydrogen by microbes. Volatile Fatty Acid (VFA) fermenters create hydrogen as a byproduct of fermentation, however, this hydrogen is estimated to be only 15% of the hydrogen that could be produced from the energy present in the organics.<sup>3</sup> Further hydrogen production is not energetically favorable. An MEC applies a voltage across the microbial environment, and provides a location especially suited for hydrogen formation on the cathode, thereby increasing that hydrogen output.<sup>4</sup> Experimentation revealed that without electrolysis, the cultured rumen fluid produced little to no gas, whereas electrolyzed rumen fluid had a high hydrogen output.

In addition to using an MEC, the methanogens in the rumen fluid had to be inhibited. Methanogens are a large proportion of the microbial population of rumen fluid, and they

consume the hydrogen that is produced and convert it to methane. Since hydrogen is the desired end-product, it is imperative that they be removed. Methanogens are extremely susceptible to heat and acid treatments.<sup>5</sup> For this project, a 24-hour incubation under acid conditions (pH 3.0) was used to inhibit the methanogens and increase pure hydrogen production.

### Propulsion Reactions

Listed in Table 1 are the chemical reactions that will be used for propulsion, as well as any well-characterized side reactions that have a significant (>30%) chance of occurring under standard operating conditions. Unless otherwise noted, all thermodynamic data was obtained from Thauer et al. “Energy conservation in chemotrophic anaerobic bacteria.”<sup>6</sup>

**Table 1. Propulsion Reactions**

Reaction	$\Delta H^\circ_{\text{rxn}}$ (kJ/mol)	$\Delta G^\circ_{\text{rxn}}$ (kJ/mol)
<b>Microbial Electrolysis Main Reactions (Occur preferentially in order listed)<sup>3</sup></b>		
$C_6H_{12}O_6 + 4H_2O \rightarrow 2H_3COO^- + 4H_2 + 2HCO_3^- + 4H^+$	Unknown	-206.3 <sup>3</sup>
$C_6H_{12}O_6 + 2H_2O \rightarrow CH_3CH_2CH_2COO^- + 2HCO_3^- + 3H^+ + 2H_2$	Unknown	-254.8 <sup>3</sup>
$C_6H_{12}O_6 + 12H_2O \rightarrow 6HCO_3^- + 6H^+ + 12H_2$	Unknown	+3.2 <sup>3</sup>
<b>Rumen Microbial Fermentation Side Reactions<sup>7</sup></b>		
$C_6H_{12}O_6 \rightleftharpoons 2 CH_3COCOO^- + 6H^+ + 2H_2$	Unknown	-112.1
$CH_3COCOO^- + 2H^+ + 2e^- \rightleftharpoons CH_3CH(OH)COO^-$	Unknown	-43.1
$CH_3COCOO^- + H_2O \rightleftharpoons CH_3CO_2^- + CO_2 + 2H^+ + 2e^-$	Unknown	-47.3
$CH_3COCOO^- + 4H^+ + 4e^- \rightleftharpoons CH_3CH_2COO^- + H_2O$	Unknown	-123.0
$CH_3COHCOO^- + 2H^+ + 2e^- \rightleftharpoons CH_3CH_2COO^- + H_2O$	Unknown	-79.9
$2CH_3COCOO^- + H^+ \rightleftharpoons CH_3CH_2CH_2COO^- + 2CO_2$	Unknown	-159.0
$2CH_3COCOO^- + 7H^+ + 6e^- \rightleftharpoons CH_3CH_2CH_2CH_2COO^- + CO_2 + 2H_2O$	Unknown	-48.1
$2CO_2 + 7H^+ + 8e^- \rightleftharpoons CH_3COO^- + 2H_2O$	Unknown	-104.6
$CO_2 + 8H^+ + 8e^- \rightleftharpoons CH_4 + 2H_2O$	Unknown	-135.6
<b>PEM Fuel Cell Reaction</b>		
$O_2 + 2H_2 \rightarrow H_2O$	-285.830 <sup>8</sup>	-237.129 <sup>8</sup>

### Propulsion Hazards

AIChE classifies some chemicals as hazards under the categories listed in Table 2, and requires identification of these compounds, or certification that these do not apply. Table 2 also lists reactants or products of the propulsion system and references the appendices that indicate how that hazard will be managed.

**Table 2. Propulsion Hazards**

Hazard	Qualification	Chemical Species that Qualify as Hazard	Description of Attachments
Pressure	Any car that produces gases with a pressure greater than 1 psig	NA	NA
Biohazard	Design, construction, or operation includes the use of living organisms other than the end users	Bovine Rumen Fluid	Email from UW biosafety officer
Other	Any species with a NAFPA rating greater than 2	Hydrogen gas	Calculations demonstrating that discharged hydrogen is well below LFL

### Bill of Materials

Table 3 lists the materials that are required to build all apparatuses required for the propulsion reactions and drive system. Note that not all of these materials will be physically on the car during the competition.

**Table 3. Propulsion Bill of Materials**

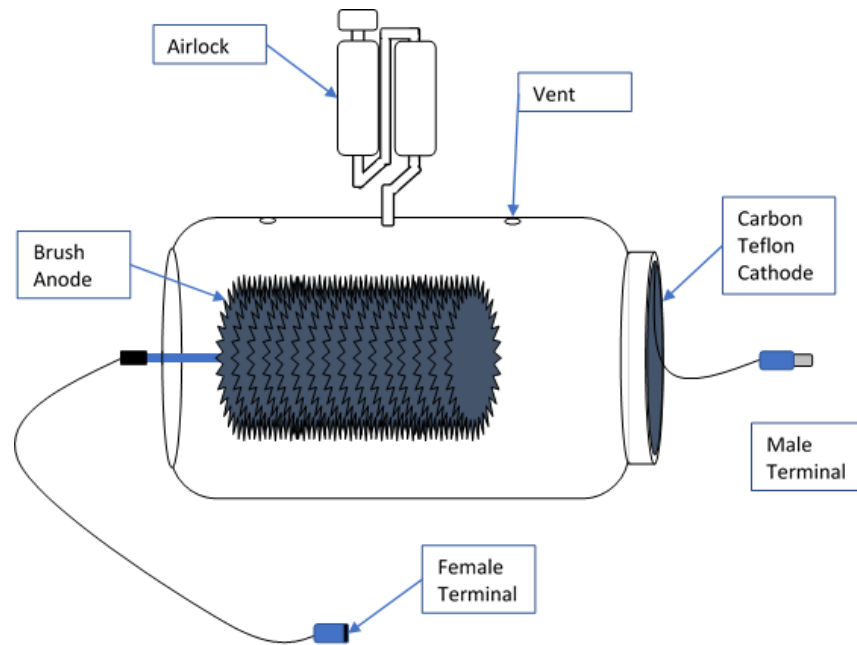
Item	Supplier(s)	Price per unit	Quantity
<b>Microbial Electrolysis Cell</b>			
Mott's 24 oz Applesauce jars	Walmart	\$2.99	6
25 ft 20-gauge titanium wire	Amazon	\$8.75	1
3 pk Brewer's airlocks	Amazon	\$5.49	2
25 pk Rubber Stoppers	Amazon	\$13.99	1
5 oz Tube of White Lixel silicone sealant	Ace Hardware	\$9.99	1
50 g Vulcan Black Powder	Fuel Cell Store	\$50.00	1
250 mL Teflon suspension solution	Fuel Cell Store	\$78.00	1
Teflon-coated carbon cloth	FuelCell.com	\$95.00	2
Carbon Fiber Anode Brush Item# 313830	Millrose Company	\$11.18	6
Cal-Test Banana Jack, 6xBlack; 6xRed	Digi-Key	\$1.29	12
<b>Motor and Wires</b>			
K'nex Imagine Motorized Building Set	Amazon	\$33.50	1
Wooden Dowel	Bloedorn Lumber	\$2.29	1
Aluminum Foil	Safeway	\$1.49	1
Carol 22-Gauge Hookup Wire, 1xBlack; 1xRed	Grainger	\$14.00	2
Masking Tape	Chem Stockroom	\$9.07	1

Item	Supplier(s)	Price per unit	Quantity
Cal-Test Banana Plug, 6xBlack; 6xRed	Digi-Key	\$0.95	12
<b>Car Body</b>			
Painted aluminum chassis	Previous ChemE Car team		1
Generic 5"-wide Tupperware dish	Walmart	\$6.30	1
<b>Electrolysis Equipment</b>			
HP Model 721A DC Power Supply	Borrowed from UW Electronics Shop		1
Quincy Lab 12-140 Incubator	Amazon	\$465.00	1
3/16" inner-diameter PVC Tubing (ft)	Chem Stockroom	\$1.74	3
30 mL Gas Storage Cylinders (x2)	Fuel Cell Store	\$17.00	6
Cored Butyl Stopper (to fit airlock)	Chem Stockroom	\$1.93	6
Vacuum Connector Assortment	Ace Hardware	\$8.55	2
<b>Hydrogen Fuel Cells</b>			
Horizon Mini PEM Reversible Fuel Cell	Fuel Cell Store	\$58.59	5

## Assembly Instructions

### Microbial Electrolysis Cells

A schematic of an MEC is given in Figure 1. Completed microbial electrolysis cells can be seen in Figure 2 through Figure 4. Refer to these figures for relative placement of the parts during assembly.



**Figure 1. Diagram of Microbial Electrolysis Cell Apparatus with Labeled Parts**  
*Courtesy of Ben Staldine, Used with permission*

Figure 2 and Figure 3 show a side and isometric view of a microbial electrolysis cell in use. Note that the wire placement means that this MEC is currently in use as a microbial fuel cell (MFC) to generate electrical power, and not hydrogen. The apparatuses are completely interchangeable. The isometric view is provided to show a clear view of the cathode.



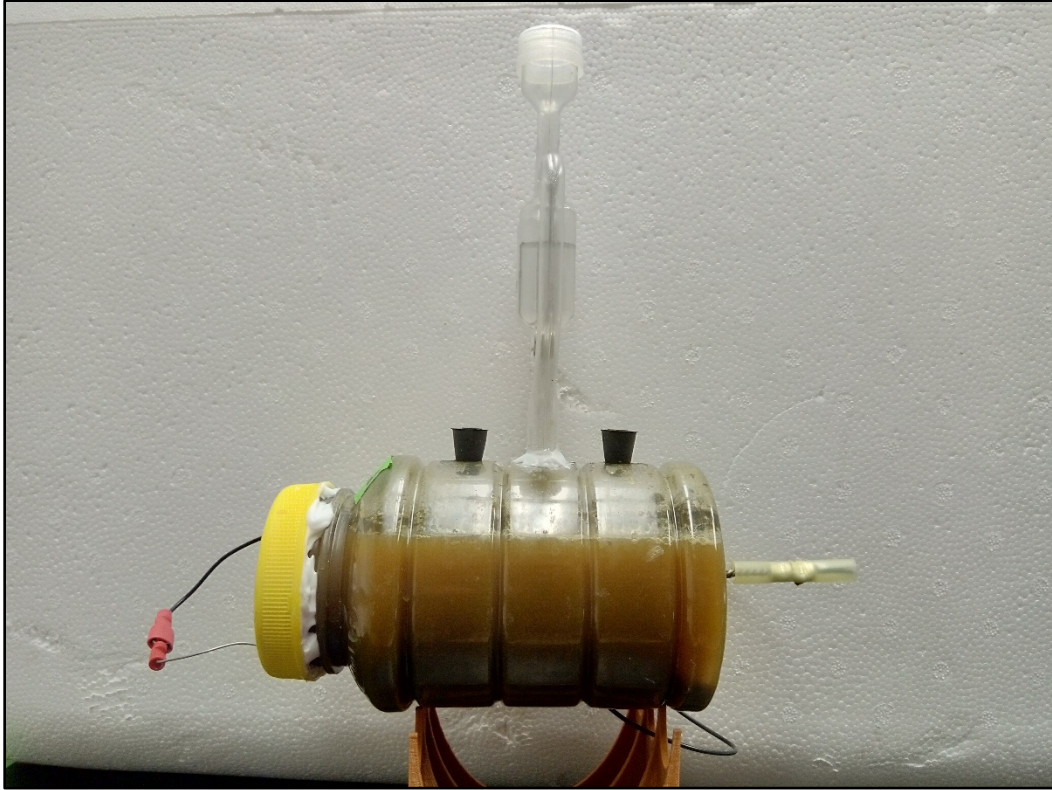


Figure 2. Side View Photograph of Microbial Electrolysis Cell Apparatus



Figure 3. Isometric View Photograph of Microbial Electrolysis Cell

Figure 4 provides a side view of an empty microbial electrolysis cell, allowing for a clear view of the carbon fiber brush anode and its placement within the MEC chamber.

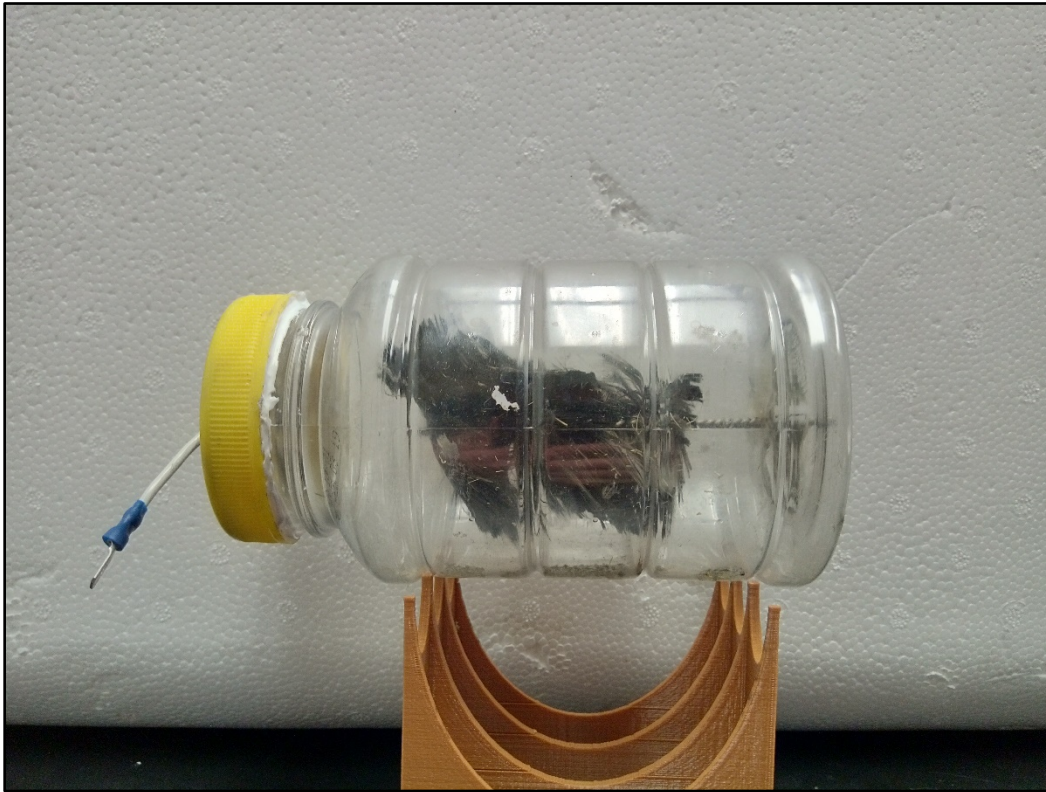
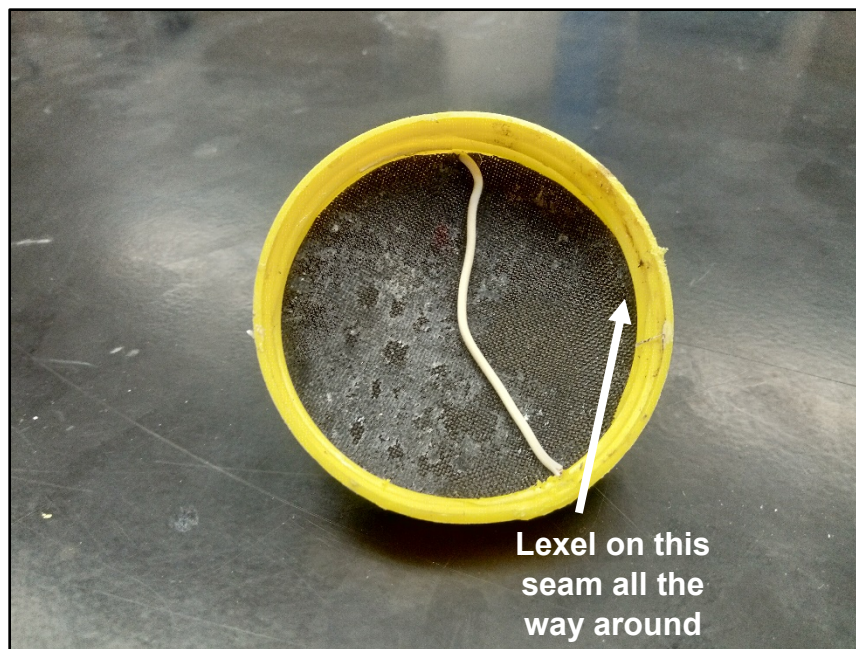


Figure 4. Side View of Empty Microbial Electrolysis Cell

1. Chamber Preparation
  - 1.1. Remove applesauce from applesauce jar
  - 1.2. Clean applesauce jar, taking care to preserve the lid ring and insert
  - 1.3. Drill one 0.030" hole in the center of the bottom of the applesauce jar
  - 1.4. Mark a straight, vertical line up the side of the jar, perpendicular to the ridges on the jar
  - 1.5. Drill a 0.112" hole in the center of the jar along the line. Be sure not to overlap any ridge with the hole
  - 1.6. Drill two 0.079" holes along the line on either side of the first hole
2. Cathode Preparation
  - 2.1. Prepare a carbon-reinforced PTFE (Teflon) solution by mixing 1.00 g of Vulcan Carbon Black Powder, 12.0 mL 60% Teflon suspension, and 4.0 mL of distilled water in a vial
  - 2.2. Cut out a 3" square of carbon cloth and affix it to a piece of cardboard with metal pins in the corners
  - 2.3. Using a paintbrush, coat the carbon cloth on one side with the carbon-reinforced Teflon solution made in step 2.1. **IMPORTANT:** Devise a system so you can remember which side you coated. You **MUST** work the same side for the **ENTIRE** process!
  - 2.4. Blowdry the wet side of the painted carbon cloth for at least 5 min using a hairdryer on medium heat. If a blowdryer is unavailable, air-dry the cathode for at least 2 hr.
  - 2.5. Remove cathode from cardboard and place in furnace at 370 °C
  - 2.6. Wait 30 min

- 2.7. Remove cathode from furnace and allow to cool at room temperature until it may be handled comfortably, but for no less than 10 min
  - 2.8. Apply coat of 60% Teflon suspension to previously coated side of cathode
  - 2.9. Blowdry for at least 1 min until cathode turns solid white color
  - 2.10. Place in furnace for 10 min
  - 2.11. Repeat steps 2.5-2.10 three more times
  - 2.12. Using razor knife and applesauce jar lid insert, cut cathode to same size as insert. You should be able to lay insert on the cathode and hold the knife blade against it as a guide
  - 2.13. KEEP TRACK OF WHICH SIDE IS COATED! THIS PIECE IS THE KEY TO THE ENTIRE APPARATUS!
3. Assembly
    - 3.1. Cut stem of airlock so that the tapering is removed, but ensure it can still reach into the jar fully through the middle hole on the side. The more stem removed, the easier further steps will be
    - 3.2. Hold airlock stem nearly flush with inside of jar. Seal seam with Lexel. NOTE: you may wish to find some way to prop the airlock in place while the Lexel seals
    - 3.3. Place anode brush into jar with stem facing through the hole in the bottom of the jar: the tip of the brush should be 2 cm from the mouth of the jar. Seal seam in the bottom with Lexel
    - 3.4. Cut length of wire that is twice the diameter of the cathode. Strip one half of its length of insulation.
    - 3.5. Fill inside corner of jar lid ring with copious amount of Lexel around the entire circumference
    - 3.6. Fold the wire over the cathode such that the exposed wire runs along the diameter of the cathode on the non-coated side
    - 3.7. Place the cathode and wire into the lid with the coated side facing the outside of the lid. Lexel the end of the wire to the cathode, and ensure good contact between the wire and cathode over its entire length. Figure 5 shows what this looks like from the inside of the lid before Lexel has been placed. Note that an insulated wire was used for visibility.





**Figure 5. Inside of Cathode Lid Conjunction**

- 3.8. Place another coat of Lexel around the edge of the jar lid ring
- 3.9. Once the components set in Lexel have set and are relatively firm, place copious amounts of Lexel in the threads of the jar lid ring. Screw the lid tightly unto the jar
- 3.10. Allow to set for 24 hrs before use

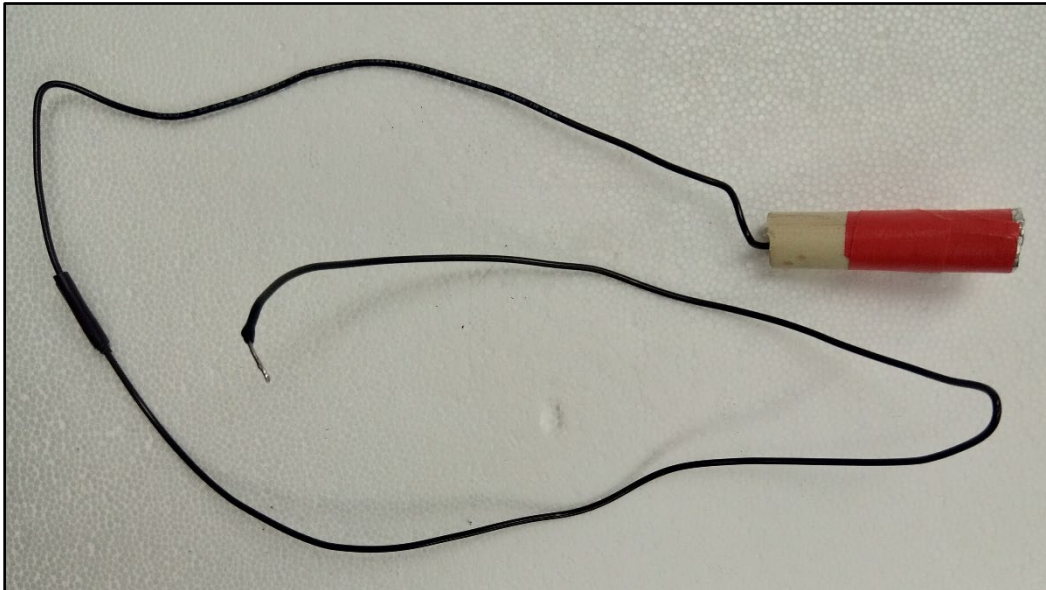
### Car Body and Motor

#### 1. Motor Adaptation

This procedure modifies the k'nex motor (which normally operates on two AA batteries) to allow current to be directly applied to the terminals inside of the battery chamber.

- 1.1. Cut the wooden dowel into two pieces the length of a AA battery
- 1.2. Drill a hole just large enough for the connector wire to pass through along the length of the dowels through the center
- 1.3. Cut a piece of black wire to about 1 ft and strip the end
- 1.4. Pass the stripped end through the hole in one of the dowels
- 1.5. Wrap the stripped wire over the side of the dowel. Stripped wire should be coming out of the hole, and fold over running back up the side of the dowel
- 1.6. Affix the wire to the side of the dowel using masking tape
- 1.7. Cut a piece of aluminum foil to fit over one end of the dowel. Place it over the end with the stripped wire coming out, then hold tightly and affix it in place with a piece of masking tape around the circumference of the dowel. Ensure there is good contact between the foil and the wire

- 1.8. Wrap the entire side of the dowel in one layer of masking tape. The results should look like what is shown in Figure 6



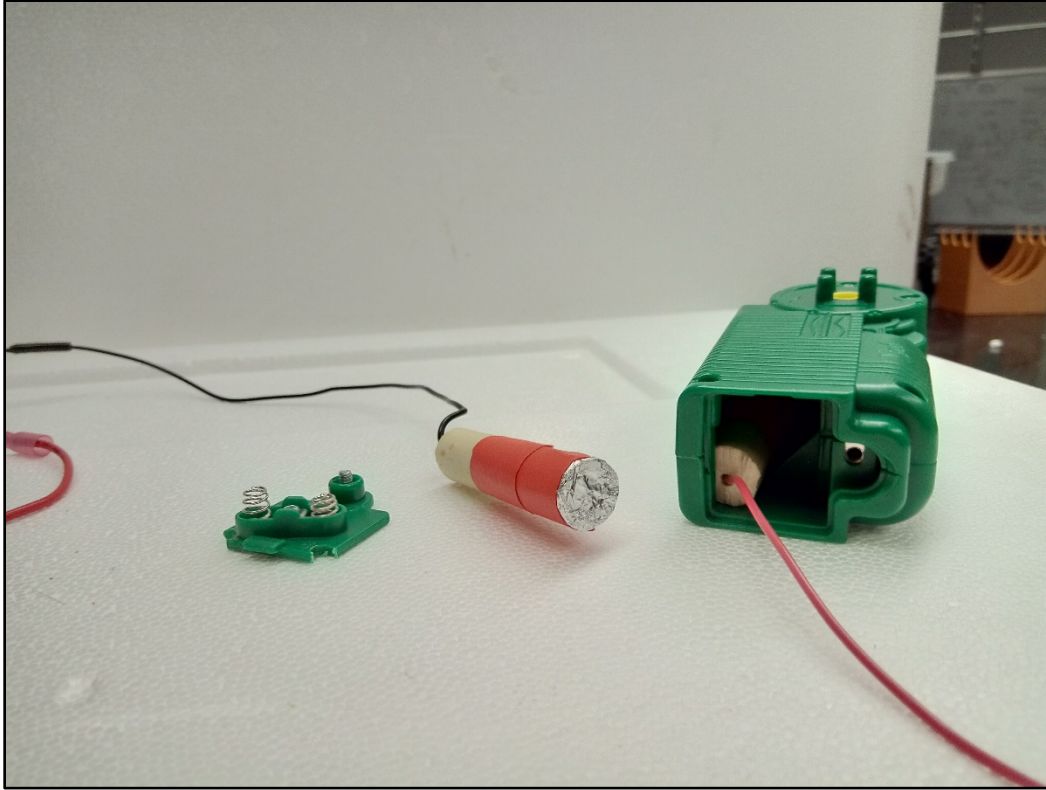
**Figure 6. Completed Battery Adapter for K'nex Motor**

- 1.9. Repeat steps 1.3-1.8 for the red wire
- 1.10. Drill holes in the lid of the battery compartment of the motor that the wires can fit out of, similar to what is shown in Figure 7



**Figure 7. Hole Locations On Battery Compartment of K'nex Motor**

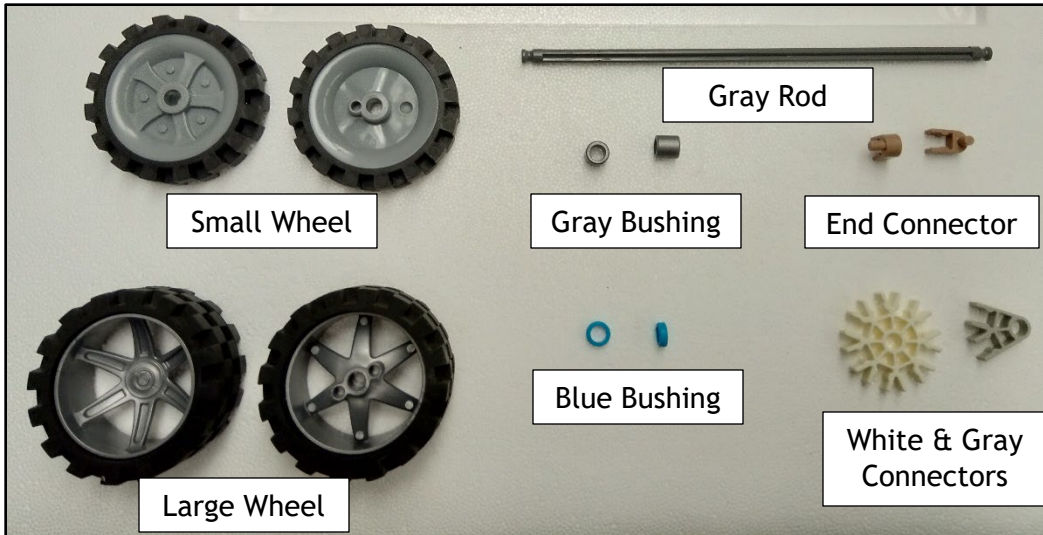
- 1.11. Place the wire/dowel apparatuses into the spaces where the batteries would normally sit. Position them such that the black wire touches the negative terminal and the red wire touches the positive terminal, as shown on the side of the motor. Figure 8 shows this arrangement for the first adapter.



**Figure 8. Placement of Battery Adapters Within K'nex Motor**

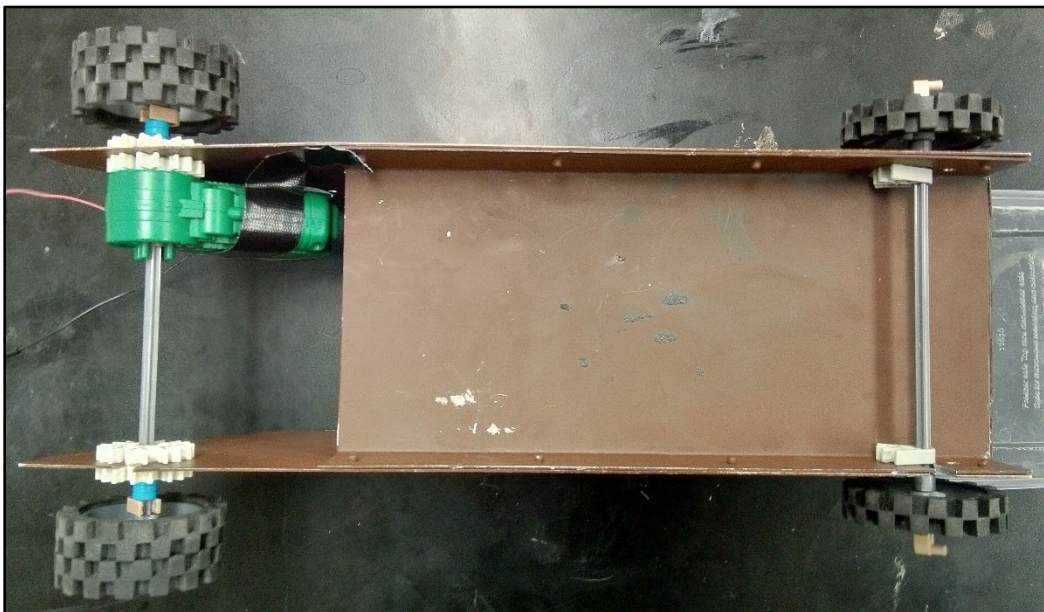
- 1.12. Thread the wires through the holes in the battery compartment
  - 1.13. Seal the battery compartment
  - 1.14. TIP: It is useful to check for continuity using the multimeter after making every connection
2. Car Assembly  
Refer to Figure 9. *K'nex Pieces and Nomenclature* for the names given to each piece and what it looks like. Every type of k'nex piece except for the motor is shown there.





**Figure 9. K'nex Pieces and Nomenclature**

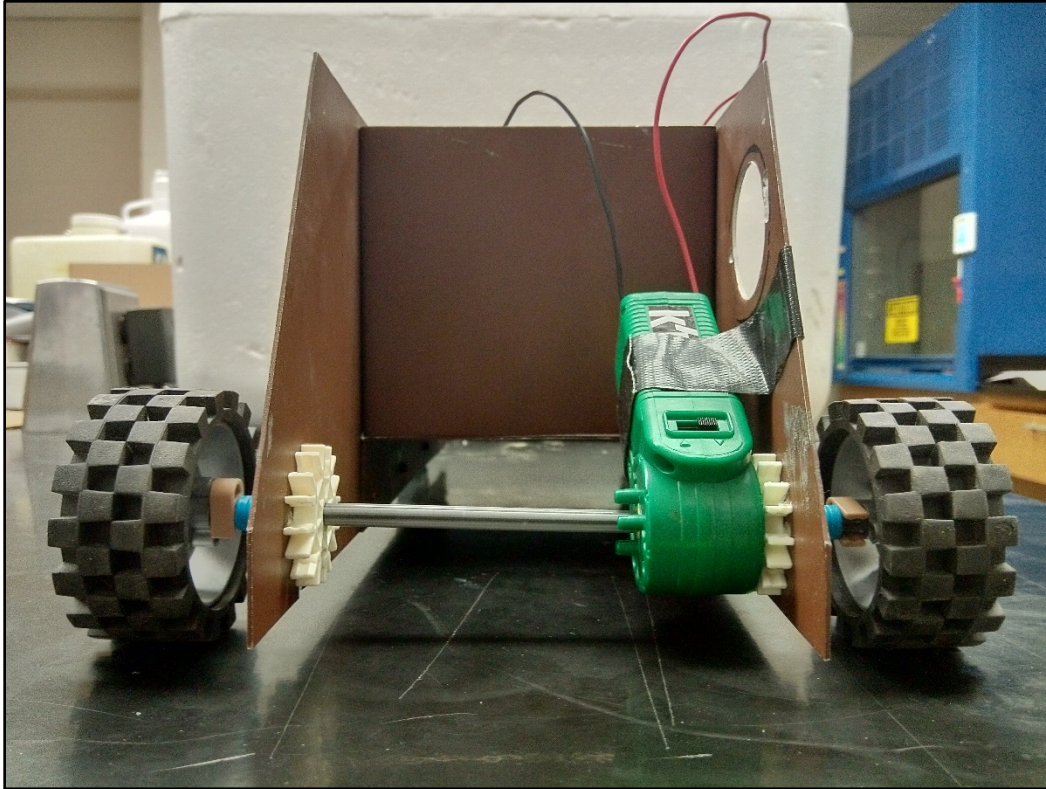
- 2.1. Using hot glue or another adhesive, affix two gray connectors to inside of car body at the back axle location so rods can pass through
- 2.2. Using hot glue or another adhesive, affix four white connectors to both inside and outside of car body at the front axle location so rods can pass through
- 2.3. Pass gray rod through back connectors to act as axle. Figure 10 shows the connector and rod positions.



**Figure 10. K'nex Pieces Locations as Seen from Bottom of Car**

- 2.4. Thread one gray bushing and one small wheel on both sides of back axle and cap the end of the rod with an end connector - the wheels should be able to move independently of the axle
- 2.5. Pass gray rod through one front connector, then through motor, then through the other connector to act as drive train and front axle

- 2.6. Thread three blue bushings unto both sides of front axle. Snap an end connector perpendicular to the axle with pin facing away from the car to hold the bushings in place
- 2.7. Snap wheels unto ends of front axle, making sure to align slots in the wheel with the pins on the end connectors
- 2.8. Affix the motor to the connector using Gorilla tape or some other adhesive. The front axle is shown fully assembled in Figure 11



**Figure 11. Front Axle and Drive Assembly**

3. Canvas cover
  - 3.1. Cut two pieces of canvas to be square, with the length of the sides being equal to the length of the chamber of the car body plus two inches
  - 3.2. Lay three pieces of bailing wire the length of the canvas evenly spaced on one piece of canvas and hot glue in place
  - 3.3. About one inch from the edge, affix three outside snaps using a snap setter tool
  - 3.4. About one inch from the opposite edge, affix three outside snaps using a snap setter tool
  - 3.5. Fold the canvas over the outside (button) part of the snaps and hot glue in place
  - 3.6. Fold the canvas along the remaining edges and hot glue in place
  - 3.7. Take the other piece of canvas, fold to the same dimensions as the first, and hot glue in place. The canvas cover at this stage is shown in Figure 12.





**Figure 12. Completed Conestoga-Style Snap-on Canvas Wagon Cover**

- 3.8. Bend the canvas to the wagon cover shape and place over the car body, holding the snaps flush with the top edge
- 3.9. Mark where the snaps lie on the car body
- 3.10. Hot glue inside snaps along the outside of the car body where the markings were made
- 3.11. The canvas can now be snapped unto and off the car body easily
4. Miscellaneous
  - 4.1. Take a Tupperware container and cut slots in its lip spaced as far apart as the car is wide
  - 4.2. Fit this container over the back of the car (slots should fit over the corners) and affix with Gorilla tape
  - 4.3. Use half-width Gorilla tape to secure five PEM fuel cells into two columns (making sure they remain upright). The tape can be placed in both the horizontal and vertical direction directly over the center of the fuel cells, where it will not interfere with any gas ports or electrodes
  - 4.4. Create a network of tubing such that all H<sub>2</sub> gas ports are connected to a single inlet tube and all O<sub>2</sub> gas ports are connected to a different inlet tube

## STOPPING REACTION

### Overall Description

A known concentration of cesium-137 is measured by a Geiger counter tube, which sends electronic pulses to a control unit. The control unit counts and stores the amount of elapsed pulses. Once a pre-specified number of pulses is reached, the control unit triggers a relay switch to cut power to the electric motor. The rate of pulses is controlled by aluminum shields, ranging in thickness from 0 to 6.5 mm in increments of 0.5 mm, placed between the cesium-137 and the Geiger tube.

### Further Background and Theory

The rate of radioactive decay from a given isotope is very precise and measuring it provides a way of back-calculating the time elapsed. Devices that do this are commonly referred to as atomic clocks. The time measured by an atomic clock can be altered by introducing shielding between the radioisotope and the measurement device. Common shielding materials are lead, steel, aluminum, concrete and earth.<sup>9</sup> For every unit of length of shielding materials that radiation enters, some of the radiation is absorbed by the shield and only a fraction of original amount leaves to continue on. By varying the amount of shielding, a measurement device such as a Geiger counter will observe a smaller quantity of radiation per time. The shielded cesium-137 source and Geiger counter essentially act as a kitchen timer that runs at different speeds.

### Stopping Reactions

Listed in Table 4 are the chemical reactions that will be used for propulsion, as well as any well-characterized side reactions that have a significant (>30%) chance of occurring under standard operating conditions.

Table 4. Stopping Reactions

Reaction	$\Delta H^{\circ}_{\text{rxn}}$ (kJ/mol)	$\Delta G^{\circ}_{\text{rxn}}$ (kJ/mol)
$^{137}\text{Cs} \rightarrow ^{137}\text{Ba} + \beta + \gamma$	NA	NA

### Propulsion Hazards

AIChE classifies some chemicals as hazards under the categories listed in Table 5, and requires identification of these compounds, or certification that these do not apply. Table 5 also lists reactants or products of the propulsion system and references the appendices that indicate how that hazard will be managed.

Table 5. Stopping Hazards

Hazard	Qualification	Chemical Species that Qualify as Hazard	Description of Attachments
Pressure	Any car that produces gases with a pressure greater than 1 psig	NA	NA

Hazard	Qualification	Chemical Species that Qualify as Hazard	Description of Attachments
Biohazard	Design, construction, or operation includes the use of living organisms other than the end users	NA	NA
Other	Any species with a NAFPA rating greater than 2	NA	NA
Special: Radioactive	NA	Cesium-137	Email from radiation safety officer, radiation exposure calculations

### Bill of Materials

Table 6 lists the materials that are required to build all apparatuses required for the propulsion reactions and drive system. Note that not all of these materials will be physically on the car during the competition.

**Table 6. Stopping Bill of Materials**

Item	Supplier(s)	Price per unit	Quantity
Aluminum Shields (0 to 6.5mm thick, in increments of 0.5 mm)	Keithley Instruments	*	NA
10 $\mu$ Ci Cesium-137 Source	Images Scientific Instruments	\$130.00	10
Scrap Wood	Truss Build, Cheyenne	\$0.02	1
GCK-02-02 Geiger Counter	Images Scientific Instruments	\$108.40	1
Industrial Strength 2" Wide Velcro	Amazon	\$9.47	1
SPDT 1-Amp 5V Relay Switch	RadioShack	\$5.00	1
National Instruments myRIO-1900	National Instruments	\$598.80	1
Geiger Counter Case	3-D Printed at Coe Student Innovation Center	\$8.00	1
Digilent myRIO Breadboard Expansion	National Instruments	\$19.99	1
Miscellaneous Electronics (See Figure 13 for descriptions)	NA		NA
250 mL Glass Beaker with Paper Packing	UW Chemical Stockroom	\$4.39	1

\*Donated and no longer manufactured, so no price could be established

### Assembly Instructions

1. Assemble Geiger Counter according to manufacturer's specifications
2. Apply Velcro to back of Geiger counter box and side of car body, allowing Geiger counter to ride on side of car

3. Assemble relay switch assembly as shown in Figure 13 and Figure 14 on the Digilent breadboard

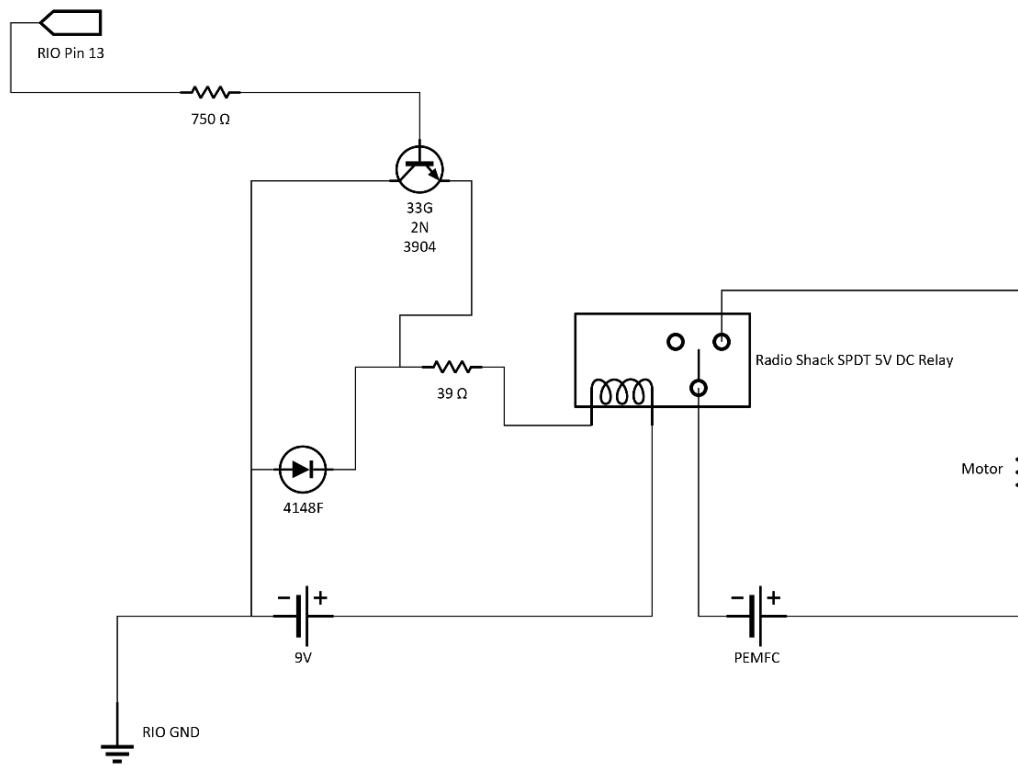


Figure 13. Circuit Diagram for myRIO and Relay Switch Interface

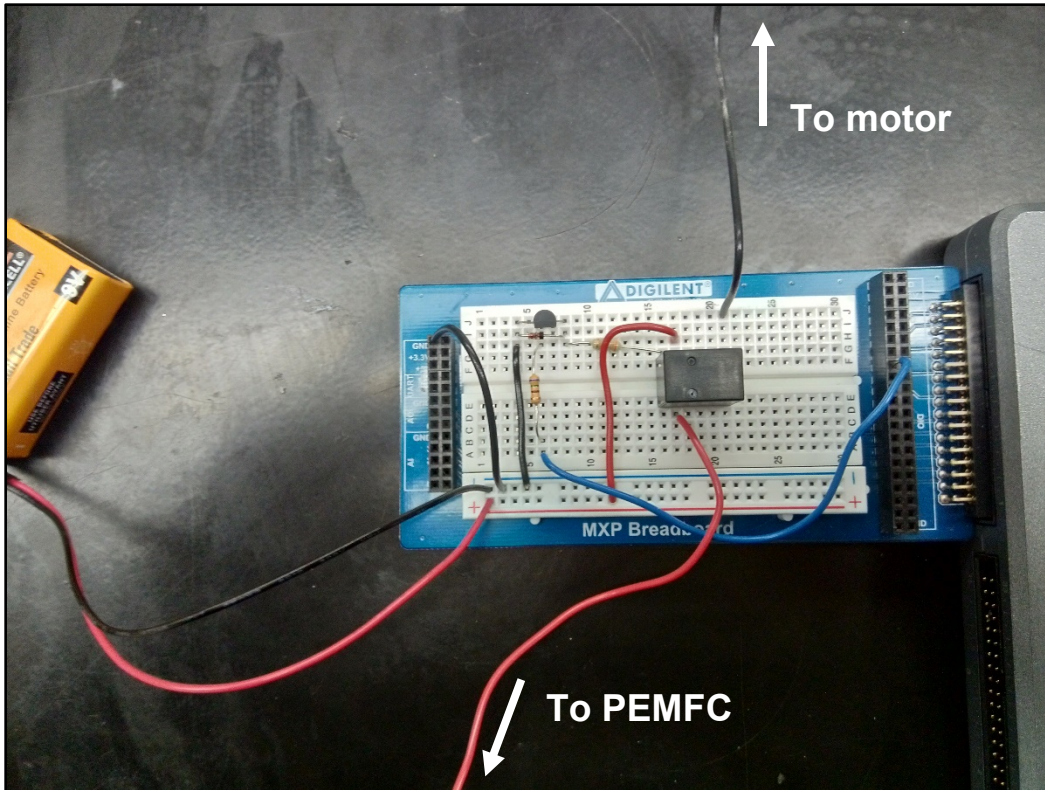


Figure 14. Photograph of myRIO Relay Switch Interface

4. Cut block of wood to be 3 ½” square (the width of a standard 2x4, meaning you should only have to make one cut)
5. In the middle of a 2”x4” face of the block, drill a hole centered in the long direction, and almost touching one of the long edges just big enough and deep enough so the Geiger tube can slide easily and fully inside
6. Use a hole saw to drill into the large face of the block such that it can fit over the beaker, but stop before reaching the Geiger tube’s hole
7. Cut a large notch parallel to the Geiger tube’s hole along the entire length of the block on one of the 2”x4” faces, but not the face that the Geiger tube’s hole is in or the one facing that face (along one of the sides)
8. This should provide a sleeve that aluminum shields can be paced into, with the Geiger tube resting over top of them, as shown in Figure 15



**Figure 15. Completed Geiger Tube- and Shield-Holder Apparatus**

9. Fill the beaker with paper packing to 240 mL as measured along the side
10. Place the cesium-137 on top of the paper packing
11. Place a single-stranded wire between terminal D on the Geiger counter and pin 14 on the myRIO breadboard
12. Place another single-stranded wire between terminal G on the Geiger counter and pin GND on the myRIO breadboard



## FLOW CHART

Figure 16 is a flow diagram describing the process by which the ChemE Car functions. All reactive chemical species and electrical power are labeled as if they were flow streams and all reaction vessels and electrical components are labeled as if they were unit operations.

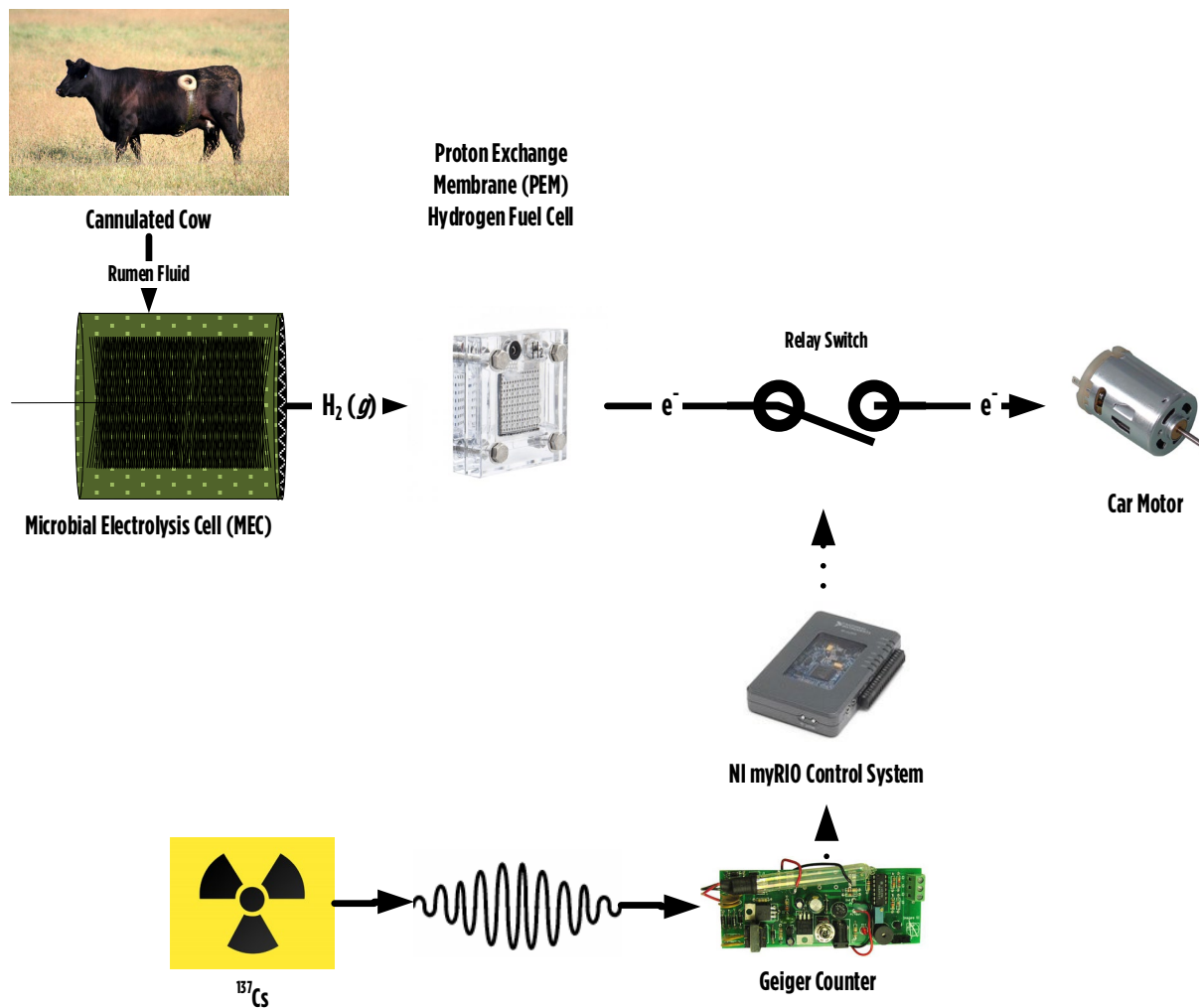


Figure 16. Process Flow Diagram of ChemE Car

## OPERATING INSTRUCTIONS

### 1) Preparation

Steps required to prepare the car for a run assuming no reactants are currently present or operating in the car

#### Phase 1 - Acid Treatment of Rumen Fluid

1. Add 0.5 mL 1 M HCl to 2 L raw rumen fluid
2. Incubate at 39° C for 24 hrs
3. Add 5 mL 0.11 M NaOH to rumen fluid

#### Phase 2 - Electrolysis

1. Add 3.5 g glucose, 0.25 g cysteine, 0.25 g sodium phosphate monobasic and 0.25 g sodium phosphate dibasic to 500 mL acid treated rumen fluid as described above in a 500 mL plastic sealable jar
2. Shake well
3. Pour half of rumen fluid solution into empty MEC apparatus
4. Reseal solution and shake well once more
5. Pour remaining half of rumen fluid solution into MEC apparatus
6. Seal one hole of MEC
7. Add distilled water to airlock to "MAX" label
8. Add distilled water to gas collection vessel labeled "H<sub>2</sub>", making sure to fill both inside and outside of bell to the "0" mark
9. Place stopper with connector barb into top of MEC airlock
10. Connect gas collection vessel to barb on MEC using PVC tubing
11. Using the airgun, flush one 12 g cartridge of CO<sub>2</sub> through the MEC chamber, taking care that all CO<sub>2</sub> passes through the chamber but does not flow too rapidly that the chamber will overpressurize and cause the MEC to rupture
12. Immediately seal the second hole on the MEC
13. Use the forceps to seal the end of the tubing closest to the collection vessel
14. Remove the tubing from the gas collection vessel, allowing the sparge gas to escape
15. Add or remove water to bring the level back to the "0" mark
16. Reaffix the tubing on the collection vessel, and remove the forceps
17. Place the MEC into a boiling hot-water bath for up to 30 min
18. Connect anode to negative terminal and cathode to positive terminal of DC power supply, and supply 0.6 V of potential across the MEC
19. Incubate and allow hydrogen to accumulate in the gas collection vessel

In order to make best use of time, this phase should be executed on as many MECs as are available all at once. Figure 17 shows this arrangement in a laboratory incubator.





**Figure 17. Microbial Electrolysis Cells Generating Hydrogen in Incubator**

### Phase 3 - Oxygen Generation

1. Fill O<sub>2</sub> side of PEMFCs with distilled water
2. Wait three minutes
3. Fill one H<sub>2</sub> gas collection vessel and one O<sub>2</sub> gas collection vessel to 0 mark with distilled water
4. Connect tubing from each side of PEMFCs to their respective collection vessels
5. Connect O<sub>2</sub> (positive) electrodes to positive terminal and H<sub>2</sub> (negative) electrodes to negative terminal of DC power supply
6. Ensure each PEMFC is connected to the DC power supply independently of any others. IN OTHER WORDS, THEY ARE CONNECTED IN PARALLEL, NOT SERIES AS THIS WILL DAMAGE THEM!
7. Apply no more than 3 V at 0.7 A of DC electrical power to PEMFCs

### Phase 3 - Stopping Calibration

1. Using a previously-determined calibration scheme, determine the amount of aluminum shielding required to produce the correct stopping time

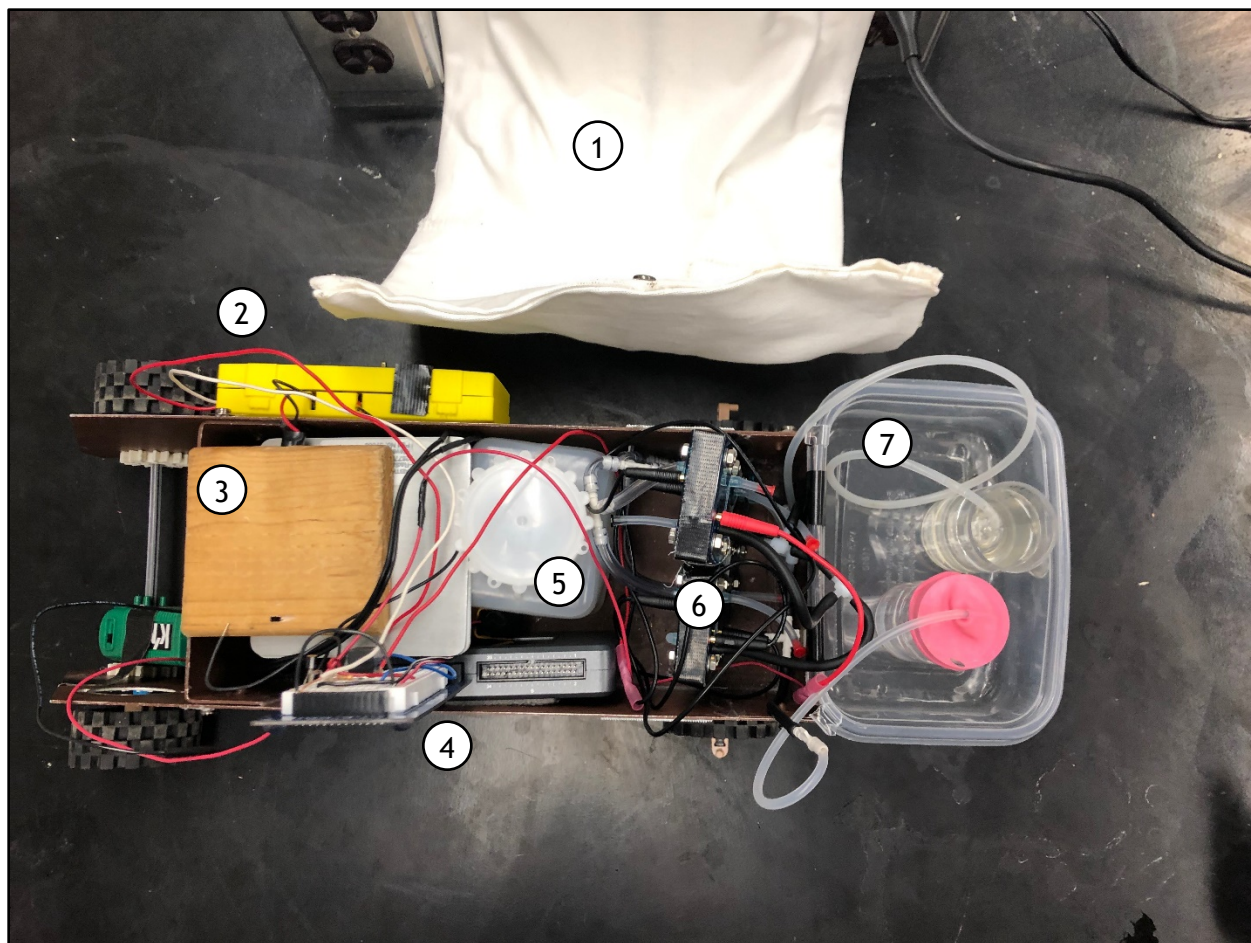
2. Place the cesium-137 source into the top of the beaker
3. Place the correct amount of aluminum into the slot in the wood block
4. Slide the Geiger tube into its hole in the wood block
5. Place the block, aluminum, and Geiger tube over the beaker with the cesium
6. Affix Geiger counter box to side of car with Velcro
7. Connect D block on Geiger counter to myRIO pin 14 and G block on Geiger counter to myRIO pin GND with single-stranded wire
8. Ensure relay, Geiger counter, and especially myRIO have fresh 9V batteries

#### Phase 4 - Hydrogen Power Generation

1. Shut off power to MECs and PEMFCs
2. Clamp MEC end of tube running to gas collection vessel with forceps
3. Clamp gas collection vessel end of tube running from H<sub>2</sub> side of PEMFCs with another set of forceps
4. Remove each tube from that end and connect together, causing the MEC-generated hydrogen to flow into the H<sub>2</sub> side of the PEMFCs
5. Disconnect PEMFCs from DC power supply and turn power back on for other MECs, if applicable
6. Connect PEMFCs in series (positive of one to negative of another), resulting in one positive and one negative terminal exposed that are not on the same PEMFC (connecting them in short-circuit will damage them)
7. Test configuration from 6 with multimeter to ensure it is correct. Voltage should be between +3-7 V
8. Connect the free positive terminal on the PEMFC block to the positive terminal on the motor
9. Connect the free negative terminal on the PEMFC block to pin D17 on the breadboard (if using the exact configuration given in Figure 14)
10. Connect the negative terminal on the motor to pin J21 (once again, if using the exact configuration given)

#### Phase 5 - Final Preparations (to be completed at the ready table)

1. Plug all electronics (Geiger counter, relay interface, and myRIO) into their 9V power supplies
2. Ensure car motor switch is set to FORWARD position
3. Place all components into the car in the places shown in Figure 18
4. Affix canvas top to car body



**Figure 18. Arrangement of All Components Within Car Body for Run**

- 1: Canvas cover
- 2: Geiger counter
- 3: Wooden block shield holder with shields and Geiger tube
- 4: myRIO control system
- 5: Water bottle (for payload)
- 6: PEMFCs
- 7: Gas collection vessels in caddy

## 2) Run

The steps that will be required to start the car from the starting line on contest day

1. Flip switch on Geiger counter to ON position
2. Press BUTTON0 on myRIO unit to reset counter and close circuit

## 3) Disposal/Cleanup

The steps to dispose of all used chemicals and return the car to the state of step 1

1. Unplug myRIO, Geiger counter, and relay interface from 9V batteries
2. Pull tubing from PEMFCs and allow to vent to atmosphere



3. Dispose of water from collection vessels in sink
4. Remove all wires from PEMFCs and immediately seal in airtight bag
5. Unplug all Geiger counter wires from breadboard
6. Carefully remove Geiger tube from block
7. Place Geiger counter in safe place
8. Remove cesium and store in appropriate place
9. Remove and/or disassemble all other parts from car that were not on the car prior to step 1
10. Disconnect all MECs from power
11. Remove spent rumen fluid from MECs, taking care not to pour rumen fluid through airlock
12. Fill each MEC fully with water, and pour into same container as spent rumen fluid
13. Dispose of spent rumen fluid in approved way. If no instructions are given, flushing down the toilet is an excellent option

***Good luck at the contest!***



**Figure 19. The ChemE Car That Cud**

## REFERENCES

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## APPENDICES

### Description of Appendices

#### Appendix 1. Email from Madeline Dalrymple

An email communication from Madeline Dalrymple, UW's biosafety officer, on safety protocols and legal handling of rumen fluid

#### Appendix 2. Hydrogen LFL Calculations

Contains gas chromatograph results and calculations demonstrating that the amount of hydrogen produced is below the Lower Flammability Limit

#### Appendix 3. Email from Todd Christensen

An email communication from Todd Christensen, MS DABR, a radiation safety officer, on the legal requirements for handling cesium-137

#### Appendix 4. Cesium-137 Dose Calculations

Calculations demonstrating that the dose received from 10  $\mu\text{Ci}$  of cesium-137 is well below the occupational hazard limit

#### Appendix 5. Rumen Fluid Collection Procedure

Step-by-step procedure for how to collect rumen fluid from a cannulated cow

#### Appendix 6. NI myRIO LabVIEW Program

Block diagrams from the single virtual instrument (VI) program used as the software for the myRIO control system

#### Appendix 7. Completed AIChE Engineering Documentation Packet (EDP)/Job Safety Assessment (JSA)

Documents that were submitted for The ChemE Car That Cud in order to allow it to be entered into the Rocky Mountain Regional ChemE Car Contest 2019

#### Appendix 8. AIChE EDP Supplement Pages

Product documentation, safety data sheets, management of change forms and any additional information required by AIChE for submission to the ChemE Car Contest

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# APPENDIX 1.

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## Email from Madeline Dalrymple

An email communication from Madeline Dalrymple, UW's biosafety officer, on safety protocols and legal handling of rumen fluid

## Thomas A Christensen II

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**From:** Madeline Jean Dalrymple  
**Sent:** Monday, January 29, 2018 4:47 PM  
**To:** Thomas A Christensen II  
**Cc:** Neil M. Day  
**Subject:** Shipping Fuel Cells Containing Rumen  
**Attachments:** [REDACTED] (43 seconds) Voice Mail.mp3  
**Categories:** ~ChemE Car

Hi Thomas

Thanks you for contacting me about shipping fuel cells that contain rumen. I have cc-ed Neil Day, UW's supervisor of the Regulated Materials Management Center. He advises on shipping regulated materials as well.

Thomas, here is a summary of our phone conversation.

The rumen has microorganisms present but is not considered pathogenic. Also because it does not contain genetically modified organism, and has no preservative it is not regulated. [https://pe.usps.com/text/imm/immc1\\_014.htm#ep1001704](https://pe.usps.com/text/imm/immc1_014.htm#ep1001704)

Therefore the concern would be to triple pack it in order to contain all liquid contents in case the fuel cell leaks.

Here is a link on packing [https://pe.usps.com/text/pub52/pub52apxc\\_023.htm](https://pe.usps.com/text/pub52/pub52apxc_023.htm) or here [http://www.fedex.com/us/packaging/guides/Clinical\\_fxcom.pdf](http://www.fedex.com/us/packaging/guides/Clinical_fxcom.pdf)

About the fragility of the sample stoppers and keeping the sample warm, others may be of service, especially the company you may ship with such as Fed Ex.

I am glad to further discuss.

Good luck with your project!

Madeline Dalrymple

Biological Safety Specialist, MS, RBP, Responsible Official for Select Agents  
University of Wyoming, Office of Research and Economic Development  
Laramie, WY 82071, USA  
Desk: 307-766-2723, [mjd@uwyo.edu](mailto:mjd@uwyo.edu)

---

**From:** Microsoft Outlook **On Behalf Of** [REDACTED]  
**Sent:** Monday, January 29, 2018 3:52 PM  
**To:** Madeline Jean Dalrymple <Dalrympl@uwyo.edu>  
**Subject:** Voice Mail (43 seconds)

Hello this is Thomas Christensen and we returning your call I called you on Friday regarding shipping room and four led to another university I would be available anytime.

From here until five -- today and Monday for five class and so -- 12:30 tomorrow Tuesday but would be available to talk anytime after that -- my number is [REDACTED] -- thank you for getting back to me and I hope to talk to you soon.

HM.

Preview provided by Microsoft Speech Technology. [Learn More...](#)



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# APPENDIX 2.

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## Hydrogen LFL Calculations

Contains gas chromatograph results and calculations demonstrating that the amount of hydrogen produced is below the Lower Flammability Limit

## Discharged Hydrogen Calculations

A gas chromatography experiment run on the gas produced from the microbial electrolysis cells, gives a peak area of 7767.26 V s for the peak corresponding to hydrogen. The calibration of this machine is given by the equation  $C \left[ \frac{\mu\text{mol}}{30 \mu\text{L}} \right] = 1.18734 \times 10^{-6} A [\text{V s}]$ , where  $C$  is the concentration of hydrogen, and  $A$  is the peak area. Substituting, we have  $C = 1.18734 \times 10^{-6}(7767.26) = 9.22 \times 10^{-3} \frac{\mu\text{mol}}{30 \mu\text{L}}$ .

Converting, that gives us  $C = 3.07 \times 10^{-4} \frac{\text{mol}}{\text{L}}$ . It is well established that 1 mole of gas at Standard Temperature and Pressure (STP) occupies approximately 24 L in volume. Taking that as a concentration,  $C_{\text{air}} = 0.04 \frac{\text{mol}}{\text{L}}$ . The lower flammability limit of hydrogen is 4% (CAMEO Chemicals), meaning that we must bring the hydrogen concentration below  $C_{\text{max}} = 1.63 \times 10^{-3} \frac{\text{mol}}{\text{L}}$ . Comparing, we find that  $3.07 \times 10^{-4} \frac{\text{mol}}{\text{L}} < 1.63 \times 10^{-3} \frac{\text{mol}}{\text{L}}$ , therefore  $C < C_{\text{max}}$  and the expected hydrogen concentration is below the LFL.

## Retention Time of Compounds (since 10/28/2009)

### GC-TCD

Compound	Formula	Retention Time (min)
Oxygen	O <sub>2</sub>	2.389
Hydrogen	H <sub>2</sub>	1.764
Methane	CH <sub>4</sub>	4.258
Carbon Dioxide	CO <sub>2</sub>	6.029

Software Version	: 6.3.0.0445	Date	: 2/6/2019 1:56:09 PM
Operator	: David Bagley	Sample Name	:
Sample Number	: 001	Study	: AI-2
AutoSampler	: NONE	Rack/Vial	: 0/0
Instrument Name	: Clarus500	Channel	: B
Instrument Serial #	: 650N6021401	A/D mV Range	: 1000
Delay Time	: 0.00 min	End Time	: 7.00 min
Sampling Rate	: 12.5000 pts/s		
Sample Volume	: 1.000000 ul	Area Reject	: 0.000000
Sample Amount	: 1.0000	Dilution Factor	: 1.00
Data Acquisition Time	: 2/6/2019 1:25:54 PM	Cycle	: 1

Raw Data File : C:\Judd TCD\Judd\_Samples\_2019\_02\_06\_001.raw  
Result File : C:\Judd TCD\Judd\_Samples\_2019\_02\_06\_001.rst [Editing in Progress]  
Inst Method : c:\tcmethods\la- PSSI\_b-tcd\_new from C:\Judd TCD\Judd\_Samples\_2019\_02\_06\_001.raw  
Proc Method : c:\tcmethods\la- PSSI\_b-tcd\_new from C:\Judd TCD\Judd\_Samples\_2019\_02\_06\_001.rst [Editing in Progress]  
Calib Method : c:\tcmethods\la- PSSI\_b-tcd\_new from C:\Judd TCD\Judd\_Samples\_2019\_02\_06\_001.rst [Editing in Progress]  
Report Format File: c:\tcmethods\la- PSSI\_b-tcd\_new.rpt  
Sequence File : C:\Tcsequences\Judd\_TCD\_Sequence.seq

## DEFAULT REPORT

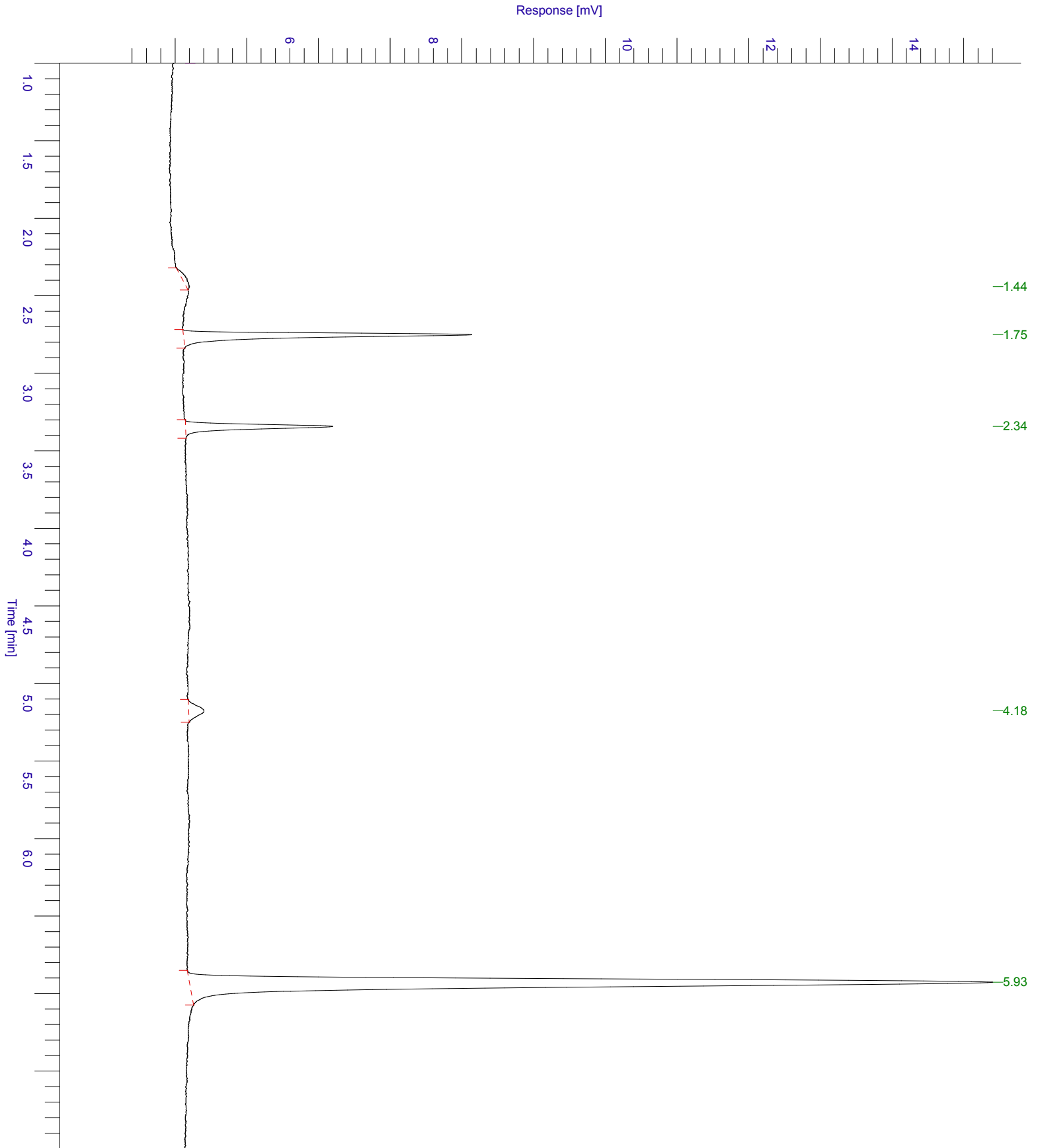
Peak #	Time [min]	Area [ $\mu$ V·s]	Height [ $\mu$ V]	Area [%]	Norm. Area [%]	BL	Area/Height [s]
1	1.442	374.52	39.50	0.72	0.72	BB	9.4805
2	1.751	7767.26	4027.30	14.89	14.89	BB	1.9287
3	2.343	4163.25	2052.59	7.98	7.98	BB	2.0283
4	4.175	928.64	211.44	1.78	1.78	BB	4.3921
5	5.927	38946.49	11206.90	74.64	74.64	BB	3.4752
		52180.17	17537.73	100.00	100.00		

Missing Component Report  
Component Expected Retention (Calibration File)

All components were found

# Chromatogram

Sample Name :                      Sample #: 001                      Page 1 of 1  
FileName : C:\Judd TCD\Judd\_Samples\_2019\_02\_06\_001.raw  
Date : 2/6/2019 1:56:27 PM  
Method : a-sssi\_b-tcd\_new                      Time of Injection: 2/6/2019 1:25:54 PM  
Start Time : 0.00 min      End Time : 7.00 min      Low Point : 4.31 mV      High Point : 16.41 mV  
Plot Offset: 4.31 mV      Plot Scale: 12.1 mV



## Thomas Allen Christensen II II

---

**From:** Judd Adam Larson  
**Sent:** Friday, November 30, 2018 4:29 PM  
**To:** Thomas Allen Christensen II  
**Subject:** Fw: GC-TCD Calibration curves

**Categories:** ~ChemE Car

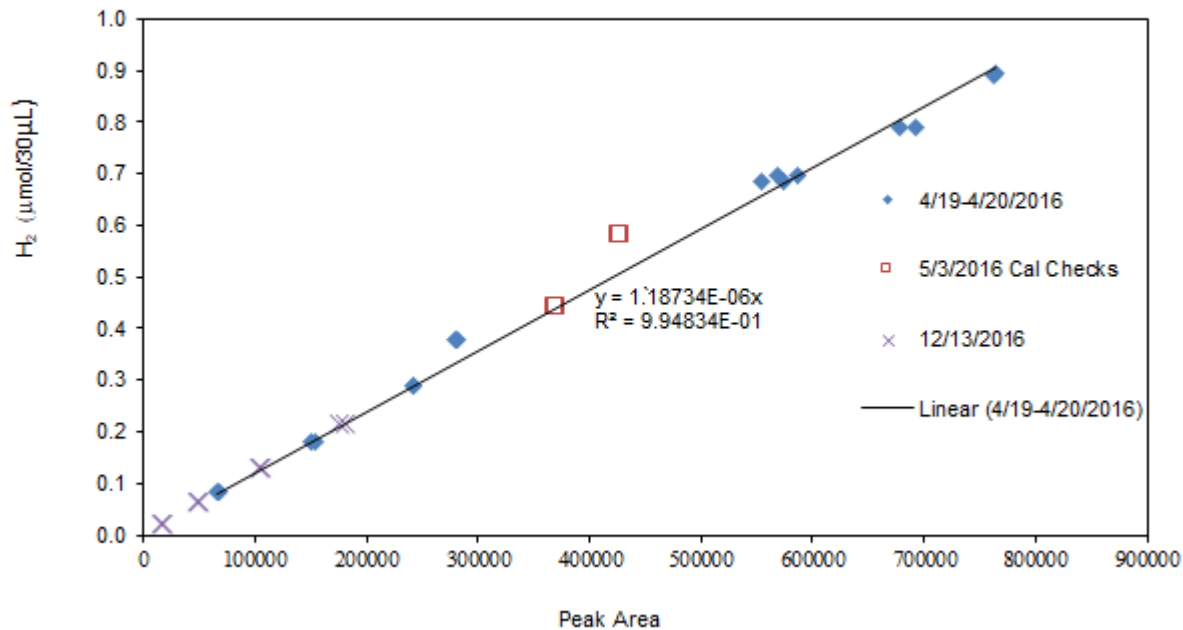
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**From:** Judd Adam Larson  
**Sent:** Thursday, April 19, 2018 5:46 PM  
**To:** Bryan Henry Cundy; Hui Cao; Hebatallah Hesham Eltoukhy; Shavinka Bihasha Fernando  
**Subject:** GC-TCD Calibration curves

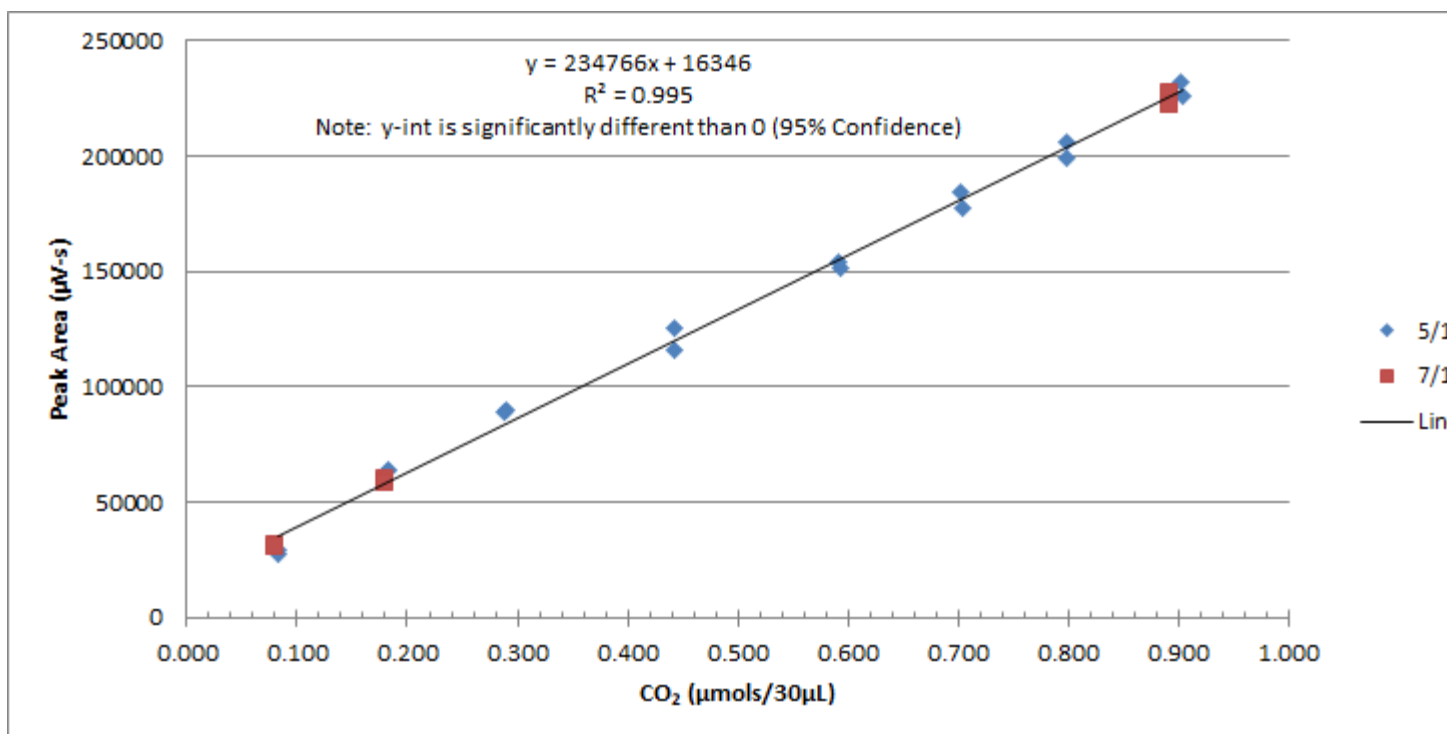
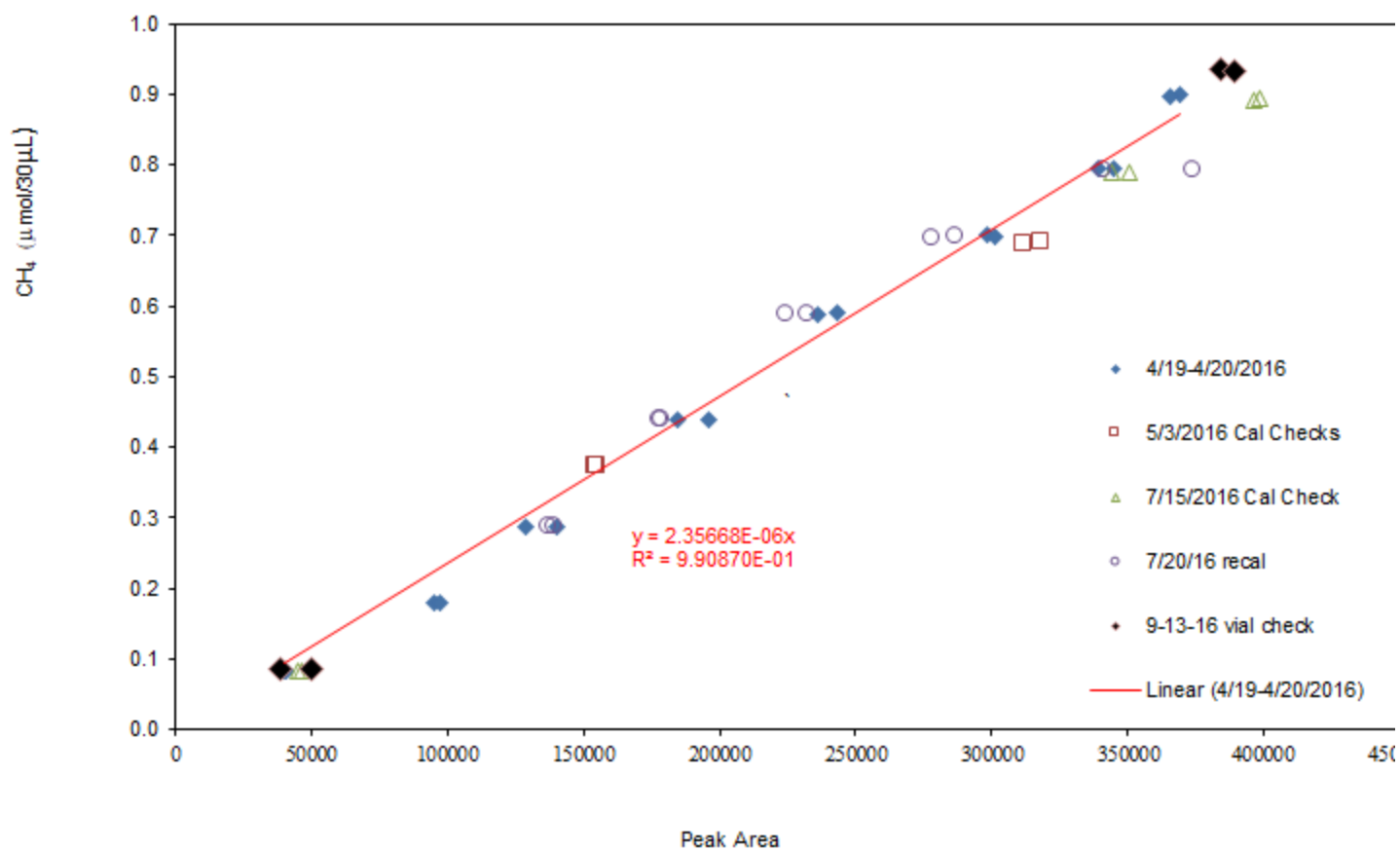
Biomethane group,

Below are the calibration curves for the GC-TCD for H<sub>2</sub>, CH<sub>4</sub>, and CO<sub>2</sub>.

**Hydrogen Standard Curve**



### Methane Standard Curve



Note: The axes are a bit different for this one.

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# APPENDIX 3.

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## Email from Todd Christensen

An email communication from Todd Christensen, MS DABR, a radiation safety officer, on the legal requirements for handling cesium-137



**Subject:** Exempt radioactive materials and the NRC

**From:** "T. Christensen" [REDACTED]

**Date:** 5/3/2017, 7:38 AM

**To:** [REDACTED]

Thomas,

Here are some links to the United States Nuclear Regulatory Commission. One is the rule explaining that you can have small quantities of radioactive materials in your possession without a license. The quantities are called "exempt" quantities. The other link is a list of radioactive materials and the amount you can possess and still be exempt. So your 10 microcurie CS137 source falls into this category. Hope this helps. If you have any further needs or questions please let me know. Good luck on your car competition.

Todd

<https://www.nrc.gov/reading-rm/doc-collections/cfr/part030/part030-0071.html>

<https://www.nrc.gov/reading-rm/doc-collections/cfr/part030/part030-0018.html>

Todd A. Christensen MS DABR  
Authorized Medical Physicist  
Radiation Safety Officer  
Pole Mountain Medical Physics, LC  
24 Snowflake Road  
Buford WY 82052  
307 274 6400

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# APPENDIX 4.

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## Cesium-137 Dose Calculations

Calculations demonstrating that the dose received from 10  $\mu\text{Ci}$  of cesium-137 is well below the occupational hazard limit

**University of Wyoming AICHe ChemE Car 2018**  
**Absorbed Dose Justification for <sup>137</sup>Cs**

The exposure rate from a radioactive source is given by

$$\frac{X}{t} = \frac{\Gamma A}{d^2}$$

Where  $X/t$  is the exposure per time,  $\Gamma$  is the exposure rate constant and  $A$  is the activity for the radioactive source in question, and  $d$  is the distance from the source at which exposure is measured [1]. For <sup>137</sup>Cs,  $\Gamma=3.28 \text{ R cm}^2 \text{ mCi}^{-1} \text{ hr}^{-1}$  [2]. Therefore, assuming that the operator stands an overly conservative average of 10 cm away from the 10  $\mu\text{Ci}$  <sup>137</sup>Cs source equipped in the ChemE Car, the exposure rate would be

$$\frac{X}{t} = \frac{3.28 \frac{\text{R cm}^2}{\text{mCi hr}} 10 \times 10^{-3} \text{mCi}}{(10 \text{ cm})^2} = 3.28 \times 10^{-4} \frac{\text{R}}{\text{hr}}$$

1 R corresponds to an absorbed dose of 0.00873 Gy [1]. Therefore

$$3.28 \times 10^{-4} \frac{\text{R}}{\text{hr}} \times \frac{0.00873 \text{ Gy}}{1 \text{ R}} = 2.86 \times 10^{-6} \frac{\text{Gy}}{\text{hr}}$$

For gamma radiation, 1 Gy absorbed dose is equivalent to 1 Sv of effective and equivalent dose [3]. NRC regulations permit an individual to receive 0.5 Sv of effective dose though occupational work per year [4]. Using the effective dose as a conversion:

$$0.5 \text{ Sv} \div 2.86 \times 10^{-6} \frac{\text{Sv}}{\text{hr}} = 1.75 \times 10^5 \text{ hr} = 19.9 \text{ yr}$$

Therefore, it would require 20 years of continuous exposure to receive the occupational limit set for one year by the NRC.

### References

1. **Johns, H. E. and J. R. Cunningham.** "The physics of radiology." 4<sup>th</sup> Ed. Charles Thomas and Company. Springfield, IL (1983).
2. **Jani, S. K.** "Handbook of dosimetry data for radiotherapy.": CRC Press, Boca Raton (1993).
3. **Wahlström, B.** "Understanding radiation.": Medical Physics Pub, Madison WI (1995).
4. **US Nuclear Regulatory Commission.** "Occupational Dose Limits." <https://www.nrc.gov/reading-rm/doc-collections/cfr/part020/part020-1201.html>, NRC, Washington, DC, May 1991.

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# APPENDIX 5.

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## Rumen Fluid Collection Procedure

Step-by-step procedure for how to collect rumen fluid from a cannulated cow

# Cow-Cudding™\* Procedure

By Thomas A. Christensen II

Rumen fluid collection is performed in so many papers, and yet the procedure is not recorded in any of them. Instead they simply say things like:

*“Samples of total rumen contents were collected via fistula”<sup>1</sup>*

*or*

*“Ruminal contents were collected via a cannula from the rumen of a fistulated Holstein cow”<sup>2</sup>*

*or*

*“Samples of rumen fluid (30 mL) were taken via the cannula every 3 h”<sup>3</sup>*

*or*

*“Rumen contents for the preparation of rumen fluid were collected via the rumen cannula of non-lactational Holstein dairy cattle”<sup>4</sup>*

In fact, some sources will lead you to believe that there’s a layer of hay sitting on top of the rumen, and once you get past that, it’s pure liquid all the way to the bottom.<sup>5</sup> If that were true, then you could just dip Dixie cups into the cow and ladle out all the rumen fluid you want. (I think someone tried that once.)

Cow cud may be a miraculous mixture, but it can be a mess if not handled properly. In order to handle it properly, you can either a) be a cow, or b) follow these handy instructions.

## You will need

- Cannulated cow
- Squeeze chute or other bovine restraint
- Large flat screwdriver
- Medium (1-gal) feed bucket
- Large (5-gal) feed bucket
- Bathtub hair strainer
- Cheesecloth
- Kitchen funnel
- Barstool
- 2-L Nalgene bottles
- OB sleeves (optional)
- Latex gloves (optional)

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\* Trademark has not actually been filed. Yet.

If you are a microbiologist, then you should replace the Nalgene bottles with pregassed glass bottles with metal lids. If you are an engineer, then the Nalgene will work just fine. For all other disciplines, contact your professional society's interruminial affairs office.

Tough Cow-Cudders™ (like myself) know that gloves are overrated. Note that the smell of rumen fluid on your hands may complicate normal everyday activities such as eating and sleeping for three days after bare skin comes into contact with rumen fluid. You have been warned.

## Directions

First, be sure to bring at least two friends with you. Rumen fluid is a “socially important microbial system,”<sup>1</sup> so it is required to make a party out of sticking your arm into a cow. I've found that groups of three usually work best for this procedure.

Serious note: these instructions assume you or someone with you has experience handling livestock. If not, have the cannulated cow's handler help you with the process.

1. Restrain cannulated cow using bovine restraint
2. Remove cannula plug using large flat screwdriver
3. Cut cheesecloth into 1 ½ ft-long sections, give one to each person
4. Place barstool with medium bucket on it about one pace away from cannula
5. Place large bucket next to barstool
6. Reach into cow and pull out one handful of rumen contents  
TIP: As the cow gets emptier, you will be able to reach deeper and pull out the juicier cud, which is what you want
7. Wrap handful of rumen contents in cheesecloth
8. Squeeze juices from rumen contents through cheesecloth into medium bucket
9. Remove solid rumen contents from cheesecloth and place into large bucket
10. Repeat Steps 6 through 9 until medium bucket is full  
TIP: You can usually rotate through these steps one person at a time in an assembly-line fashion
11. Pour rumen fluid from medium bucket through funnel and strainer into Nalgene bottles taking care to seal each bottle with no air on top as it becomes full
12. Repeat steps 6 through 11 until all Nalgene bottles are full
13. Take this time to explore the structures of the rumen while the cow is mostly empty. Be sure to check out:
  - a. The papillae: Basically the sandpaper-like structure on the rumen wall
  - b. The reticulum: Reach way to the front of the cow, then sweep your hand backwards along the rumen floor until you feel it trapped by a layer of tissue
  - c. The omasum: From the reticulum, reach toward the cow's right side and feel a large, round, hard structure through the rumen wall
  - d. Rumen contractions: If you haven't already been caught by one of these, leave your arm deep in the rumen and wait for up to two minutes and the cow will squeeze all of the rumen contents tightly, including your hand
14. Place the solid rumen contents back into the cow
15. Run hot water over the cannula plug until it is very pliable

16. Return the cannula plug into the cannula by collapsing it along its diameter then squeezing it straight into the hole. Stop as soon as the lip of the cannula plug fits under the lip of the cannula
17. Put the cow back into her pen
18. Wash off all your equipment
19. Use or refrigerate the rumen fluid ASAP

And that is Cow-Cudding™. 100% satisfaction guaranteed†.

## References

1. Kenters N, Henderson G, Jeyanathan J, Kittelmann S, Janssen PH. Isolation of previously uncultured rumen bacteria by dilution to extinction using a new liquid culture medium. *J Microbiol Methods*. 2011;84(1):52-60. doi:10.1016/j.mimet.2010.10.011
2. Rismani-Yazdi H, Christy AD, Dehority BA, Morrison M, Yu Z, Tuovinen OH. Electricity generation from cellulose by rumen microorganisms in microbial fuel cells. *Biotechnol Bioeng*. 2007;97(6):1398-1407. doi:10.1002/bit.21366
3. Dias RS, Patino HO, López S, Prates E, Swanson KC, France J. Relationships between chewing behavior, digestibility, and digesta passage kinetics in steers fed oat hay at restricted and ad libitum intakes<sup>1</sup>. *J Anim Sci*. 2011;89(6):1873-1880. doi:10.2527/jas.2010-3156
4. Chin-Tsan W, Che-Ming Y, Zih-Sheng C, Yao-Cheng L. Performance of straw-fed microbial fuel cells with mixed rumen microorganisms by using different catholytes. *Biomass Bioenergy*. 2013;59:412-417. doi:10.1016/j.biombioe.2013.08.033
5. Thomas HS. *The Cattle Health Handbook: Preventive Care, Disease Treatments & Emergency Procedures for Promoting the Well-Being of Your Beef or Dairy Herd*. North Adams, MA: Storey Pub.; 2009.

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† Terms and conditions apply

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# APPENDIX 6.

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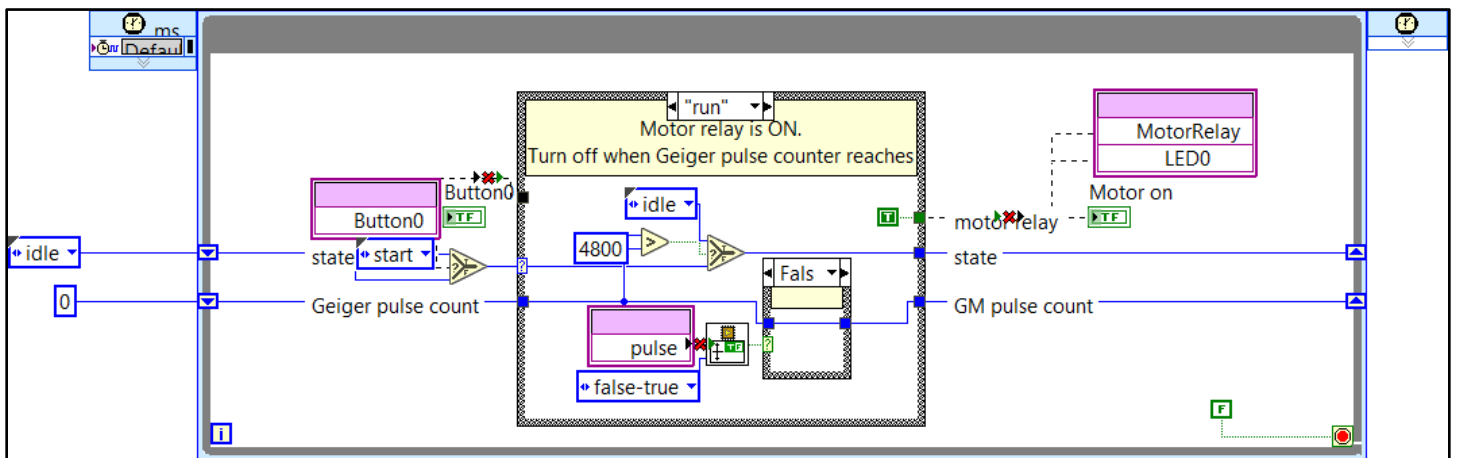
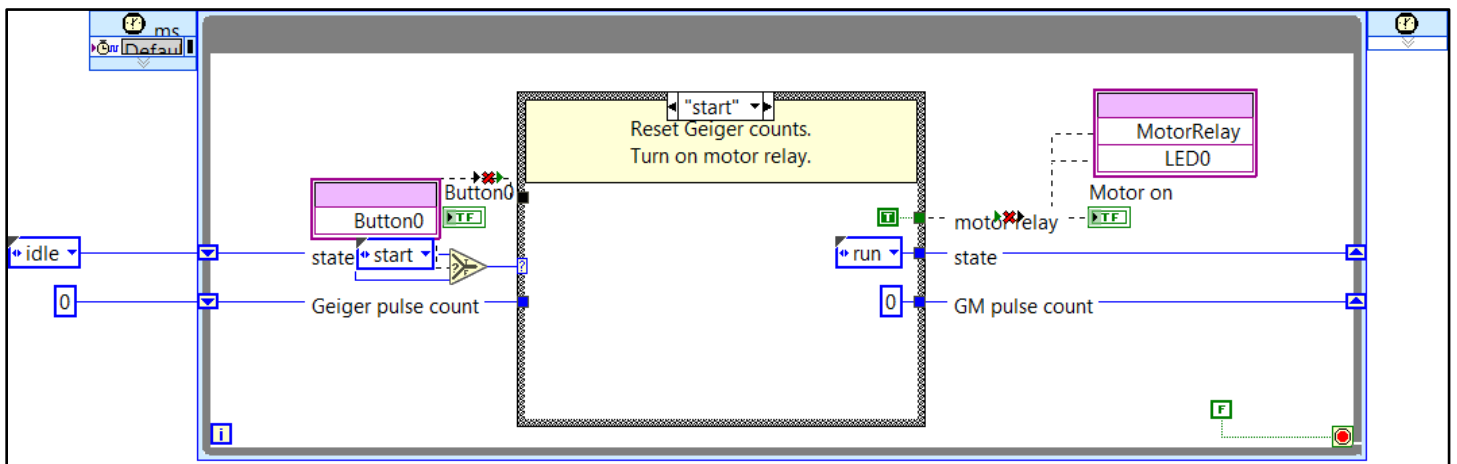
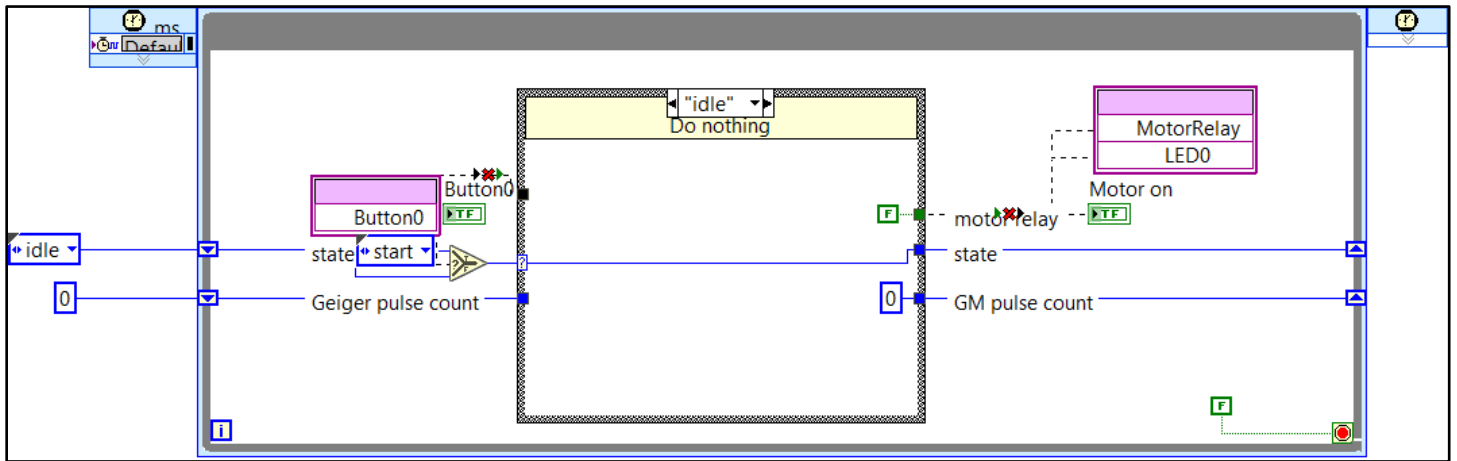
NI myRIO LabVIEW Program

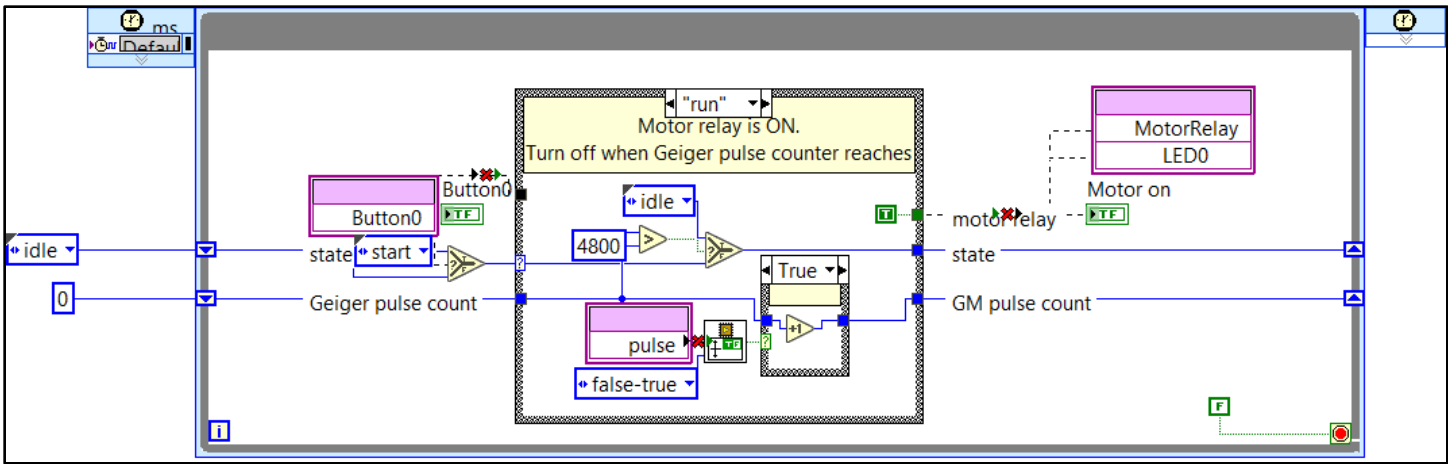
Block diagrams from the single virtual instrument (VI) program used as the software for the myRIO control system



## control.vi

- To be compiled and deployed as the startup FPGA program for the NI myRIO 1900
- Shown in all logic states below
- Source code available at: <https://dev.azure.com/ahalver2/myRIO-e10s/code/>





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# APPENDIX 7.

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Completed AIChE Engineering Documentation Packet (EDP)/Job Safety Assessment  
(JSA)

Documents that were submitted for The ChemE Car That Cud in order to allow it to be entered into the Rocky Mountain Regional ChemE Car Contest 2019



**Job Safety Assessment Form**  
**Chem-E-Car Competition**  
**2019 Regional Competitions**

<b>University:</b> University of Wyoming	<b>Vehicle Name:</b> The ChemE Car That Cud
<b>JSA Author/Team Captain Name:</b> Thomas A. Christensen II	
<b>Team Captain Email:</b> tchris13@uwyo.edu	
<b>Faculty Supervisor:</b> David M. Bagley	<b>Supervisor Email:</b> bagley@uwyo.edu
<b>Revision #:</b> 10	<b>Revision Date:</b> Thursday, April 4, 2019

**Car operation, hazards, and safety:** Describe your Chem-E-Car's design, intended mode of operation (propulsion system), intended mode of control (stopping mechanism), and major hazards and their control. [Attach additional page(s) if necessary]

**Describe your car's design:**

The ChemE Car that Cud showcases Wyoming's dominant industries of agriculture and mining by utilizing rumen fluid from a cannulated beef cow to generate hydrogen to be used in a hydrogen fuel cell and radioactive cesium, a byproduct of uranium that is often obtained from Wyoming's mines, to time the car's stop. The concentration of Cesium-137 source is measured using the radioactive decay of cesium shielded by aluminum. The painted aluminum chassis was obtained from a previous team at UW and modified using plastic k'nex toys to adapt to the current power source and stopping mechanism.

**Power source (propulsion system):**

The hydrogen fuel cell utilizes biologically derived hydrogen to power an electric motor. Hydrogen is produced in a microbial electrolysis cell inoculated with bovine rumen fluid fed by glucose. A voltage applied across an inoculum of bovine rumen fluid consuming glucose as a substrate allows the microorganisms to reduce aqueous protons ( $H^+$ ), producing Hydrogen gas ( $H_2$ ). This Hydrogen gas generated in batch is collected and fed to a Proton Exchange Membrane Fuel Cell (PEMFC). The PEMFC reduces Oxygen ( $O_2$ ) by reacting  $O_2$  with the protons generated from the oxidation of Hydrogen gas, producing water ( $H_2O$ ). The movement of protons across the membrane creates an electric gradient, producing a current and powering the motor.

**Stopping mechanism:**

A known concentration of Cesium-137 is measured by a Geiger counter tube, which sends electronic pulses to a control unit. The control unit counts and stores the amount of elapsed pulses. Once a pre-specified number of pulses is reached, the control unit triggers a relay switch to cut power to the electric motor. The rate of pulses is controlled by aluminum shields ranging in thickness from 0 to 6.5 mm in increments of 0.5 mm placed between the Cesium-137 and the Geiger tube.

**Hazards inherent in design:**

1. Biological - The use of microorganisms as the power source for the car
2. Radiation - The presence of the radioactive isotope,  $^{137}\text{Cs}$
3. Electrical - The potential for exposed electrical wires to shock operators
4. Hydrogen gas - The potential of exposition from H gas ignited by a spark from the electrical wires
5. Oxygen gas – The ability of oxygen to enhance flammability of other compounds

**Safety measures:**

1. Biological - Microorganisms from the rumen of ruminant animals are not considered pathogenic. Regardless, no eating or drinking is allowed in a space where rumen fluids are present and operators are required to wear gloves while handling rumen fluids and/or wash hands with soap afterwards as well as wear safety glasses under standard microbiological lab practices.
2. Radiation - The radiation for the is car comes from a  $10\ \mu\text{Ci}$   $^{137}\text{Cs}$  source sealed in a plastic shell. This quantity and species of radioactive source is considered exempt from radiation safety measures by the NRC.  $^{137}\text{Cs}$  emits beta- and gamma-radiation but the operator is shielded from all beta-radiation by the plastic shell.  $^{137}\text{Cs}$  emits so little gamma-radiation that it would take 20 years of continuous exposure at 10 cm to the gamma radiation in order to receive the occupational limit set for one year's radiation exposure by the Nuclear Regulatory Commission. As  $^{137}\text{Cs}$  is exempt from radiation safety measures by the NRC, it can be appropriately disposed of in traditional waste receptacles or can be stored in the lab with appropriate labeling in the recycled and reused by design teams at a later date.
3. Electrical – The operator is protected by all electrical components by the appropriate insulation on wires and cases housing circuit boards. All connections are made using screw blocks inside of an insulated case or disc insulated connectors.
4. Hydrogen gas – The vehicle's power is derived from 40mL of hydrogen ( $\text{H}_2$ ) gas which is stored in a hydrogen containment vessel (in the form of an inverted bell vessel within a plastic beaker).
5. Oxygen gas – Oxygen gas is stored in containment vessels rated for oxygen service which have never been used for any other compounds.

**Please list the major design changes for your car, and how it is different from the vehicle your School/Team used for last year's competition (If your school did not compete in the Chem-E-Car Competition in the previous year, you can leave this section blank):**

N/A

**Expected Operating Conditions :**

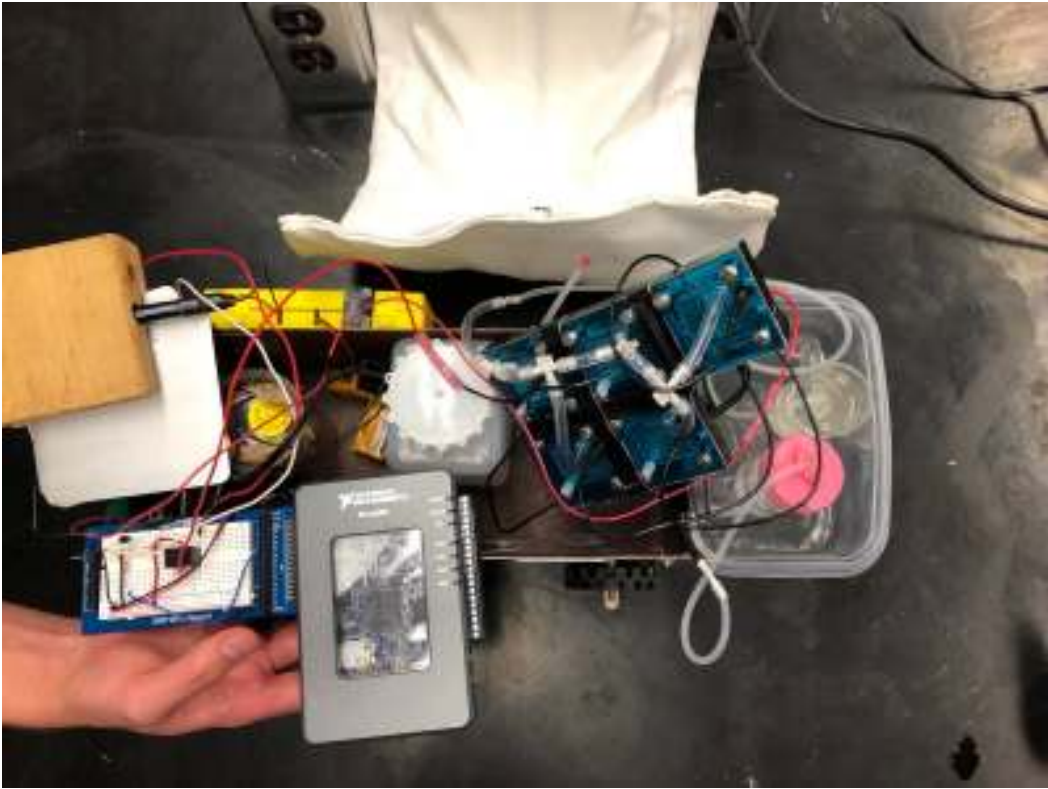
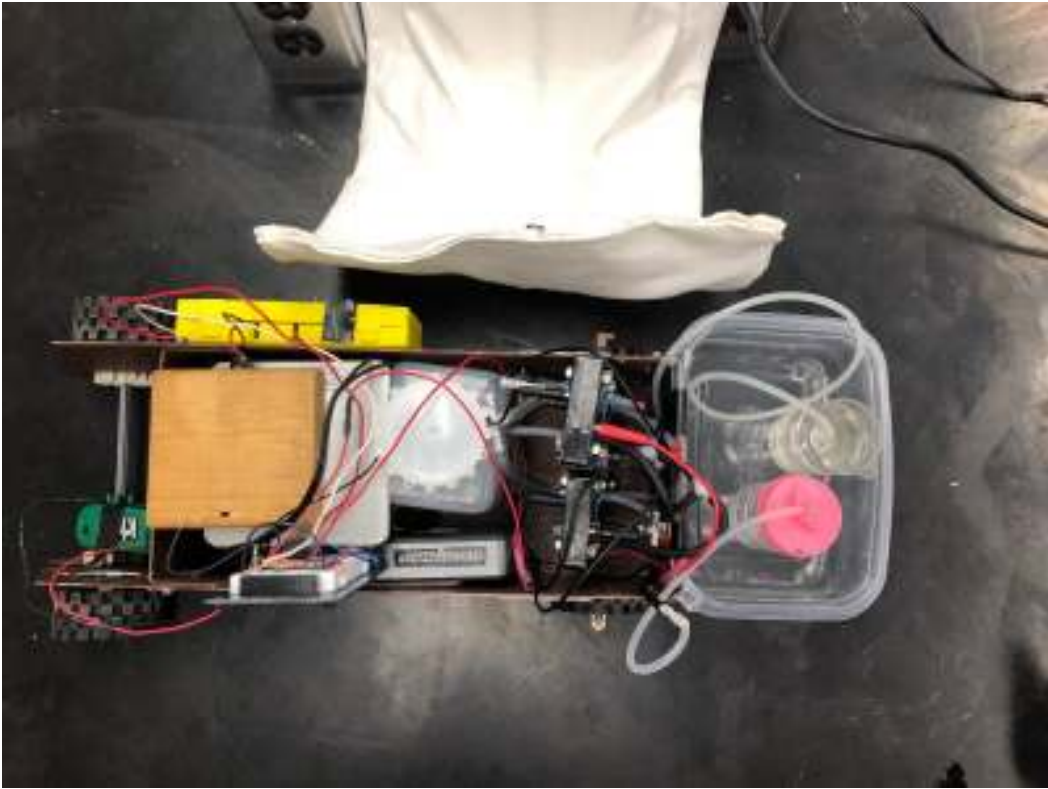
Temperature: 20-35°C

If your car generates pressure above 1 psig, please list the Maximum Operating Pressure (MOP) and the Maximum Allowable Working Pressure (MAWP): N/A

## Photos of Completed Vehicle:

Please add a photo or photos of your vehicle after construction has been completed. These pictures must be current. The entire car must be visible in at least one picture. Remove the top to expose electrical controls if necessary. Multiple views of the car are encouraged. A drawing or AutoCAD document will NOT be accepted







**Request for Power Outlet at Competition Site:** If your team requires a power outlet at your table at the competition, please provide reasoning here. Please note that outlets requested to plug in laptops at your table will not be granted.

Power outlets will be required in order to run our incubator, to keep our microbial electrolysis cells at operating temperature, and to provide the constant voltage across the electrolysis cells, thereby accommodating the hydrogen production.



The Global Home of Chemical Engineers

### Certifications Page

2018 Regional Chem-E-Car Competition®

University: University of Wyoming	Vehicle Name: The ChemE Car That Cud
Primary Student Contact Name: Thomas A. Christensen II	Email: tchris13@uwyo.edu
Faculty Supervisor: David M. Bagley	Email: bagley@uwyo.edu

#### 1. Required Safety Training:

Date and location of required Chem-E-Car safety training for faculty advisor:

Advisor Name David M. Bagley Safety Training Location EN 3109  
 Safety Training Date Dec. 6, 2018

List below each student team member and the date and location of safety training:

Team Member Name	Location	Date
<u>Thomas A. Christensen II</u>	<u>Engineering Room 3109</u>	<u>12/6/2018</u>
<u>Amade V. Christensen</u>	<u>Engineering Room 3109</u>	<u>12/6/2018</u>
<u>Alexander Brown</u>	<u>Engineering Room 3109</u>	<u>12/6/18</u>
<u>Andrew Halverson</u>	<u>Engineering Room 3109</u>	<u>12/6/18</u>
<u>Seth Messick</u>	<u>Engineering 3109</u>	<u>12/6/18</u>
<u>Jake Maksin</u>	<u>Engineering E 3109</u>	<u>12/6/18</u>
<u>Kenneth Trice</u>	<u>Engineering 3109</u>	<u>12/6/18</u>
<u>Casey Richmond</u>	<u>ENG 3109</u>	<u>12/6/18</u>
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

#### 2. Faculty Certification:

I certify that this student team has followed all of the safety and competition rules, has completed an engineering documentation package, has completed a safety review under my supervision or with an outside expert, and has at least ten hours of operating experience beyond the time required to design and assemble the car:

Faculty Advisor Name David M. Bagley

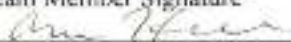







Faculty Advisor Signature David M. Bagley Date 2-20-19

Outside Expert Name \_\_\_\_\_

Outside Expert Signature \_\_\_\_\_ Date \_\_\_\_\_

**3. Student Certification:**

We certify that we have followed all of the safety and competition rules, have completed an engineering documentation package, have completed a safety review with our faculty supervisor or with an outside expert, and have at least ten hours of operating experience beyond the time required to design and assemble the car:

Team Member Signature	Date
	2/20/19
	2/20/19
	2/20/19
	2/20/19
	02/20/2019
	2-20-19
	2/20/19
	2/20/19

**Submission instructions:** Teams must submit this form with their Regional EDP. Print off both pages, have team members and your advisor sign and then scan the document and include it with your EDP.

**Team Name:** The ChemE Car that Cud  
**Student Chapter:** University of Wyoming

**1. Briefly describe the propulsion system (reaction/mechanism) of your vehicle.**

The hydrogen fuel cell utilizes biologically derived hydrogen to power an electric motor. Hydrogen is produced in a microbial electrolysis cell inoculated with bovine rumen fluid fed by glucose. A voltage applied across an inoculum of bovine rumen fluid consuming glucose as a substrate allows the microorganisms to reduce aqueous protons ( $H^+$ ), producing Hydrogen gas ( $H_2$ ). This Hydrogen gas generated in batch is collected and fed to a Proton Exchange Membrane Fuel Cell (PEMFC). The PEMFC reduces atmospheric Oxygen ( $O_2$ ) by reacting  $O_2$  with the protons generated from the oxidation of Hydrogen gas, producing water ( $H_2O$ ). The movement of protons across the membrane creates an electric gradient, producing a current and powering a motor.

**2. Describe the reaction that your vehicle uses to stop at the designated finish line.**

A known concentration of cesium-137 is measured by a Geiger counter tube, which sends electronic pulses to a control unit. The control unit counts and stores the amount of elapsed pulses. Once a pre-specified number of pulses is reached, the control unit triggers a relay switch to cut power to the electric motor. The rate of pulses is controlled by aluminum shields, ranging in thickness from zero to 6.5 mm in increments of 0.5 mm, placed between the cesium-137 and the Geiger tube.

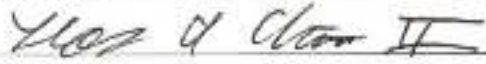


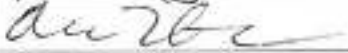


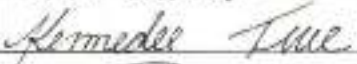

**3. Provide a precise answer to the following question: If your vehicle is 3 m short of the designated finish line on the first run, what specific changes will your team make to the stopping reaction to correct the shortfall? Assuming the original distance was 20 m (which is significant due to our non-linear calibration curve), we would remove 2 mm of Aluminum shielding from between the  $^{137}Cs$  source and the Geiger counter tube.**



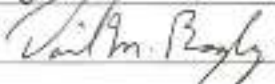
## Safety and Rules Verification Form Page 2

We, the undersigned team members, leaders and advisor of the University of Wyoming (University) Chem-E-Car Competition team, do hereby verify that we have complied with all rules and safety requirements posted on the AIChE Chem-E-Car Competition® Web page. If we qualify (or our team is on the waiting list and are informed we are able) to compete at the Chem-E-Car Competition, we understand and agree that we will not be allowed to compete in the Chem-E-Car Competition if our completed EDP package is not resubmitted by the posted deadline.

### Team Members:

Printed Name	Signature	Date
Thomas A. Christensen II		12/6/18
Amanda A. Christensen		12/6/18
Alexander Brown		12/06/18
Andrew Halverson		12/6/18
Seth Messick		12/6/18
Jake Maksin		12/6/18
Kennedee True		12/6/18
CALEB RICHMOND		12/6/18

### Team Advisor:

Printed Name	Signature	Date
David M. Bagley		Dec. 6, 2018

## Hazards Analysis

This analysis is for your home institution, not the competition site. Please attach a floor diagram of the laboratory where you will be building and testing your vehicle on the following page. List the location of available safety equipment and spill response supplies on this diagram.

### Expected Operating Conditions:

Temperature	Pressure
Normal: 35°C	Normal: 0.75 atm
Minimum: 20°C	Minimum: 0.75 atm
Maximum: 36°C	Maximum: 1 atm

**Personal Protective Equipment (PPE):** Check all PPE worn during operation of this Chem-E-Car. Do not list these in the procedure section.

<input checked="" type="checkbox"/> Long Pants	<input checked="" type="checkbox"/> Safety Glasses	<input type="checkbox"/> Hard Hat	<input type="checkbox"/> Apron
<input type="checkbox"/> Long Sleeves	<input type="checkbox"/> Splash Goggles	<input checked="" type="checkbox"/> Insulated Gloves	<input type="checkbox"/> Ear Protection
<input checked="" type="checkbox"/> Non-porous Shoes	<input type="checkbox"/> Face Shield	<input type="checkbox"/> Chemical Gloves	<input type="checkbox"/> Other:

**Available Safety Equipment** – Provide the location of each item shown below at your home institution where your vehicle will be operated and tested. Show the location of this equipment on your provided floor plan. **Answer all questions.** If not available, type “NA” in the field.

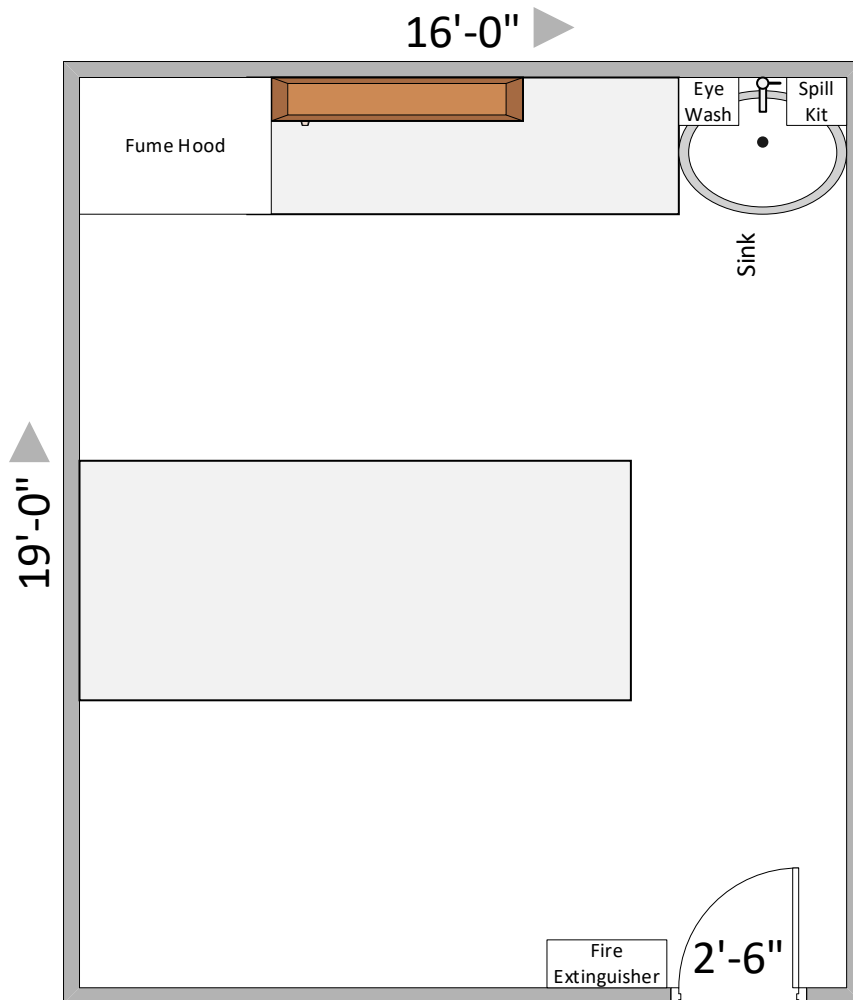
Item	Location
Fire Extinguisher:	Next to door
Eyewash:	Over sink
Safety Shower:	NA
Telephone:	NA
First Aid Kit:	NA
Spill Containment	Over sink
Other:	NA

**Spill Response Supplies** - Provide the location of each item shown below at your home institution where your vehicle will be operated and tested. Show the location of this equipment on the attached floor plan. **Answer all questions.** If not available, type “NA” in the field.

Item	Location
Spill Kit:	Over sink
Floor-Dri:	NA
Spill Dikes:	NA
Sodium Bicarbonate:	NA
Drain Plugs:	NA
Spill Pillows:	NA
Mercury Spill Kit:	NA
Other:	NA
Other:	NA

## Hazards Analysis

**Laboratory Floor Plan/Diagram:** Please insert a floor plan diagram of the laboratory where you will be building and testing your vehicle on this page. List the location of available safety equipment and spill response supplies from the previous page on this diagram.





## Hazards Analysis

**Disallowed Activities:** The activities listed below are not allowed and will result in a multi-year disqualification of your university from ChemE car competition and possible fines.

Item
(a) Transport of chemicals in private, university or rental vehicles either to or from the competition.
(b) Chemicals storage in hotel rooms or other facilities not rated for chemical storage. Approved chemical storage will be provided at the host site.
(c) Testing of vehicle in hotel or dorm hallways, warehouses, or other facilities that are not designed for chemical handling. This includes your university and the competition site.
(d) Improper disposal of chemicals at the conclusion of the competition. All chemicals shipped to the competition site must be disposed of in a safe and environmental fashion following all local, state and national regulatory measures. Chemical disposal will normally be provided by the host site.

**Disallowed Vehicles:** All of the items listed below are not allowed.

Item	Explanation
(a) Flames and/or smoke	Both inside and outside the vehicle. See Chem-E car rules for using commercial internal combustion engines. <b>Note that NO SMOKE is allowed from any vehicle, including those using internal combustion engines.</b>
(b) Liquid Discharge	Liquid(s) may not be discharged under any operating conditions.
(c) Open and/or improperly secured containers	No open containers are allowed at the starting line or during the operation of your vehicle. All containers must have secure lids and must be secured to the vehicle. All containers brought to the starting line must have lids, be properly labeled, and proper personal protective equipment must be used.
(d) Pouring of chemicals at the starting line	All chemicals added at the starting line must be contained in secure syringes, and the syringes must be left on the vehicle.
(e) Regulated Chemicals	A number of chemicals are listed by OSHA as a special hazard. See list below. OSHA has a special regulation for each chemical. See <a href="http://www.osha.gov">www.osha.gov</a> for details.
(f) Highly Reactive / Unstable Chemicals	Any chemical, raw material, intermediate or product with an NFPA reactivity / instability rating of 4.
(g) Hydrogen peroxide	Hydrogen peroxide at concentrations greater than 30% are not allowed.

**Regulated chemicals:** asbestos, coal tar pitch volatiles, 4-nitrobiphenyl, alpha-naphthylamine, methyl chloromethyl ether, 3,3'-dichlorobenzidine, bis-chloromethyl ether, beta-naphthylamine, benzidine, 4-aminodiphenyl, ethyleneimine, beta-propiolactone, 2-acetylaminofluorene, 4-dimethylaminoazo-benzene, n-nitrosodimethylamine, vinyl chloride, inorganic arsenic, benzene, 1,2-dibromo-3-chloropropane, acrylonitrile, ethylene oxide, formaldehyde, 4,4'-Methylenedianiline, 1,3-butadiene, methylene chloride.

## Hazards Analysis

**Vehicle Primary Hazards Checklist:** Check the box in the left hand column if the hazards listed below exist on the vehicle. Then check the applicable means of control for each hazard.

Hazard (check if present)	Control
<input type="checkbox"/> (a) Pressure	Anything greater than 1 psig. <b>Must meet all requirements below:</b> <input type="checkbox"/> Pressure gauge (must read to 2x max. operating pressure) <input type="checkbox"/> Emergency relief device set to no more than 1.1 times the max. operating pressure. Relief sizing calculations must be provided. <input type="checkbox"/> Emergency relief device in proper location. <input type="checkbox"/> Pressure certification – see Pressure Vessel Testing Protocol <input type="checkbox"/> Proper management system to prevent over or mis-charging. <input type="checkbox"/> All car components exposed to pressure must be certified to operate at that pressure. Provide manufacturer's pressure specifications. <input type="checkbox"/> No PVC, cPVC or polyethylene terephthalate (PETE or PET) plastics in pressure service <b>Must have measurements or calculations to prove maximum operating pressure. Max allowable pressure this year is 500 psig. See ChemE car rules for more details on these requirements.</b>
<input type="checkbox"/> (b) Toxicity	Any chemicals with an NFPA toxicity of 2 or greater. <input type="checkbox"/> Doubly contained and handled properly.
<input type="checkbox"/> (c) Flammable	Any chemicals with an NFPA flammability rating of 2 or higher. <input type="checkbox"/> Doubly contained and handled properly
<input type="checkbox"/> (d) Reactive	Any chemicals with an NFPA instability/reactivity rating of 2 or 3. <b>Chemicals with a 4 rating are not allowed.</b> <input type="checkbox"/> Doubly contained and handled properly.
<input type="checkbox"/> (e) Temperature	Any exposed surface greater than 150 deg. F or under 32 deg F. <input type="checkbox"/> Insulation or barrier to prevent contact.
<input checked="" type="checkbox"/> (f) Electrical	Exposed wiring and electrically energized components are ignition, electrocution, and a shorting/fire hazard. Alligator clips and twisted wire connections are not allowed; use binding posts or banana plugs for a more secure connection. <input checked="" type="checkbox"/> Proper electrical insulation and connections provided.
<input type="checkbox"/> (g) Mechanical	Any fast moving parts (meshing gears, belts or chains) that are pinch hazards. <input type="checkbox"/> Guards present and adequate.
<input checked="" type="checkbox"/> (h) Oxygen	All components exposed to oxygen. These must be <input checked="" type="checkbox"/> certified for oxygen service. <input checked="" type="checkbox"/> thoroughly cleaned of contaminants as per instructions in rules. <input checked="" type="checkbox"/> not used previously for other types of service.
<input checked="" type="checkbox"/> (i) Biohazards	<input checked="" type="checkbox"/> No biohazards greater than biohazard level 1 either during the design, development, preparation or competition phases of your car.

## Hazards Analysis

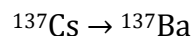
**Additional Fabrication & Operation Hazard Detail Check List:** Check all hazards that are likely to be encountered during your Chem-Car construction and operation. List the major source(s) of the hazard and describe how the hazard(s) will be controlled. If both construction and hazard columns are checked in an individual row, then the hazards should be identified separately for both the construction and operation.

Hazard	Present During		Control Method(s) <sup>1</sup>	PPE Required <sup>1</sup>
	Construction?	Operation?		
Pressure	<input checked="" type="checkbox"/>	<input type="checkbox"/>	None	Safety glasses, closed-toe shoes, long pants, Cold-insulating gloves for the CO <sub>2</sub> cartridge
Toxicity	<input type="checkbox"/>	<input type="checkbox"/>		
Flammability	<input type="checkbox"/>	<input type="checkbox"/>		
Reactivity/Instability	<input type="checkbox"/>	<input type="checkbox"/>		
Hot Surfaces/High Temp > 150 F (65 C)	<input type="checkbox"/>	<input type="checkbox"/>		
Cold Surfaces/Low Temp < 32 F (0 C)	<input type="checkbox"/>	<input type="checkbox"/>		
Electrical	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Insulation	None
Arc welding	<input type="checkbox"/>	<input type="checkbox"/>		
Gas welding	<input type="checkbox"/>	<input type="checkbox"/>		
Lathe	<input type="checkbox"/>	<input type="checkbox"/>		
Milling machine	<input type="checkbox"/>	<input type="checkbox"/>		
Handheld power tools	<input checked="" type="checkbox"/>	<input type="checkbox"/>	None	Safety glasses, closed-toe shoes, long pants
Drill press	<input type="checkbox"/>	<input type="checkbox"/>		
Other mechanical hazards	<input type="checkbox"/>	<input type="checkbox"/>		
Paint spraying	<input type="checkbox"/>	<input type="checkbox"/>		
Ionizing radiation	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Plastic containment, stored in 200 mL glass beaker	None
Laser radiation	<input type="checkbox"/>	<input type="checkbox"/>		
Asphyxiates	<input type="checkbox"/>	<input type="checkbox"/>		
Open flames	<input type="checkbox"/>	<input type="checkbox"/>		
Potential Spills	<input type="checkbox"/>	<input type="checkbox"/>		
Biohazards:	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Containment, lab practices	Safety glasses, closed-toe shoes, long pants, latex gloves (or hand washing)
Other:	<input type="checkbox"/>	<input type="checkbox"/>		

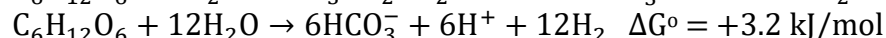
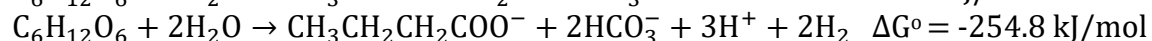
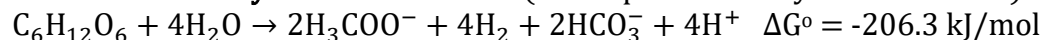
## Chemical Information

**Description of Chemistry/Chemical Reactions:** Provide details below on any chemical reaction(s) that occur in your system. Please show the reactants involved, the stoichiometry and the heat of reaction, if available. Also list side reactions and any other reactions that may impact safety.

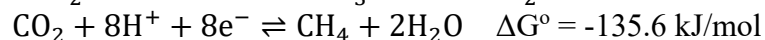
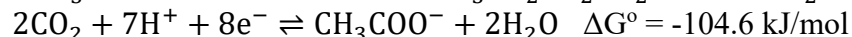
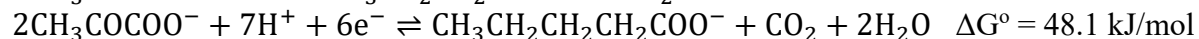
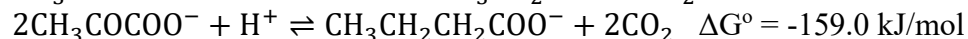
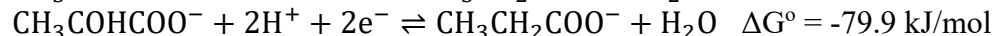
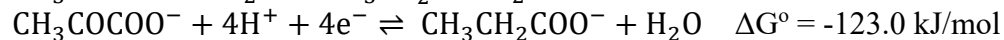
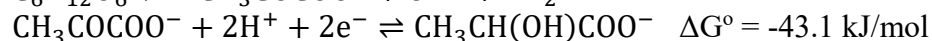
### Radioactive Decay Reaction



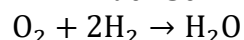
### Microbial Electrolysis Main Reactions (Occur preferentially in order listed)



### Rumen Microbial Fermentation Side Reactions



### PEM Fuel Cell Reaction



**Table 1:** Please list all chemicals, concentrations and quantities that will be shipped to competition site. This is so the Host can prepare to receive, store and transport your chemicals.

Chemical Name	Chemical State (Solid, Liquid, Gas)	Concentration (MUST include units!)	Amount To Be Sent To Competition Site
Bovine Rumen Fluid	Liquid	≥ 99.9% Pure (g/L)	4 L
Cesium-137	Solid	N/A	10 μCi
Glucose	Solid	N/A	50 g
L cysteine HCL	Solid	N/A	10 g
CO2	Gas	≥ 90% Pure (g/L)	180 g

**Note:** Please include any special storage requests that the Host should be aware of, and how many boxes you expect to ship.

The bovine rumen fluid will be shipped in an insulated container and should be refrigerated immediately upon arrival. L cysteine HCl, Glucose, and CO2 cartridges will be shipped directly from the supplier and have no special storage requirements. Cesium-137 will be shipped from UW and has no special storage requirements. There are a total of 4 shipping packages. Vinegar will be transported by the team as a “common household chemical.”

**Table 2:** Please list all chemicals that you expect to generate and dispose of during the competition. This should be WASTE/USED chemicals only.

Chemical Name	Concentration (include units!)	Amount	Waste Classification (Acid, Base, Organic, Metal, Oxidizer, Other)
Bovine Rumen Fluid	≥ 99.9% Pure (g/L)	4.5 L	Other: biological
<sup>137</sup> Cs	N/A	10 µCi	Other: exempt radioactive

**Table 3:** Please list any unused chemicals that you expect to have leftover after the competition is done. These will be donated to the Host University. These should NOT be waste/ used chemicals.

Chemical Name	Chemical State (Solid, Liquid, Gas)	Concentration (MUST include units!)	Amount Expected to be Left Over
L cysteine HCl	Solid	N/A	9 g
Glucose	Solid	N/A	36
Cesium-137	Solid	N/A	10 µCi

### Chemical Hazards and Disposal

#### Chemical Properties and Hazards for ALL CHEMICALS, including reactants, intermediates and products.

Chemical Name	Physical State (S, L, G)	NFPA Ratings*				Incompatible Chemicals List chemicals present within the laboratory, and any others that may come in contact.	Flash Point Temp.	Flammability Limits	
		H	F	S	Sp.			LFL	UFL
Bovine Rumen Fluid	L	N/A	N/A	N/A	N/A	None	N/A	N/A	N/A
L cysteine HCl	S	1	1	1	N/A	None	N/A	N/A	N/A
Glucose	S	1	0	0	N/A	N/A	N/A	N/A	N/A
Cesium-137	S	3	4	3	Radi oact ive	None	N/A	N/A	N/A
Hydrogen gas	G	0	4	0	0	Unknown (CAMEO Chemicals)	N/A	4.0	75.0
Carbon Dioxide		N/A	N/A	N/A	N/A	None	N/A	N/A	N/A

\*NFPA Ratings: H – Health, F – Flammability, S – Stability, Sp. – Special

#### Chemical Toxicology, Regulation and Disposal: List the same chemicals that appear above, in the same order.

Chemical Name	Toxicology			Hazardous Waste Number	OSHA Regulated?	Personal Protective Equipment Specific to this Chemical
	TWA	PEL	Other			
Bovine Rumen Fluid	N/A	N/A	N/A	N/A	<input type="checkbox"/>	Close-toed shoes, long pants, safety glasses
L cysteine HCl	N/A	N/A	N/A	N/A	<input type="checkbox"/>	None
Glucose	N/A	N/A	N/A	N/A	<input type="checkbox"/>	None
Cesium-137	N/A	N/A	N/A	N/A	<input type="checkbox"/>	None
Hydrogen Gas	N/A	N/A	N/A	N/A	<input type="checkbox"/>	Cold-insulating gloves, face shield
Carbon Dioxide	N/A	N/A	N/A	N/A	<input type="checkbox"/>	Close-toed shoes, long pants, safety glasses, Cold-insulating gloves

**Biohazards:** Provide details below on any biological hazards that may occur during the design, development, preparation or competition phases of your car. Please list the biological hazards, the biohazard level, and a description of how these agents will be safety handled.

Bovine rumen fluid will be the source of our anaerobic digesting bacteria used to power our fuel cell. Microorganisms from the rumen of ruminant animals are not considered pathogenic. Regardless, no eating or drinking is allowed in a space where rumen fluids are present, and operators are required to wear gloves while handling rumen fluids and/or wash hands afterwards, as well as wear safety glasses under standard microbiological practices.

### Standard / Safe Operating Procedures Page

Provide step-by-step details for each of the sections shown below. Identify the hazards, the control methods and the personal protective equipment (PPE) required. Provide adequate detail so that the reviewers of this document will have adequate understanding of your procedure to pass judgment on the safety of your vehicle.

The **Emergency Shutdown** section should have only one or two steps required to stop your vehicle and bring it to a safe state.

The **Start-Up Procedure** section should list all the steps required to prepare your chemicals and vehicle.

The **Run Time Procedure** should describe all steps to operate your vehicle at the competition starting line.

The **Shutdown Procedure** should describe the steps normally taken to shut down your vehicle at the end of your competitive run.

The **Cleanup / Waste Disposal** section should list all the steps required to clean your vehicle of all chemicals and proper chemical disposal.

Sequence of Steps	Potential Hazards	Procedure to Control Hazard	PPE or Equipment Required
<b>Emergency Shutdown</b>			
1. Switch off electric motor using switch on motor body	None	N/A	N/A
<b>Start-up Procedure</b>			
1. Add 3.5 g glucose, 0.25 g L-cysteine HCl dissolved in 500 mL rumen fluid to electrolysis cell vessel. 2. Add vinegar to electrolysis cell until pH of cell contents reaches ~ 5.0 3. Seal using anaerobic stoppers 4. Attach hydrogen collection vessel to fuel cell 4. Incubate fuel cell for a minimum of one hour while electrolyzing with a constant potential of 0.6 V. 5. Place <sup>137</sup> Cs source contained in Pyrex beaker into car body 6. Add appropriate number of aluminum shields into holder and place over Pyrex beaker container 7. Place Geiger tube in holder above Pyrex beaker	Biological Radiation Electrical	Absence of pathogens Lab procedure Exempt radiation quantity Pyrex beaker containment, plastic shielding Insulated electrical circuits	Safety glasses Close-toed shoes Long pants



8. Remove hydrogen collection vessel from electrolysis cell, place onto nozzle on car body			
<b>Run Time Procedure</b>			
<ol style="list-style-type: none"> <li>1. Remove excess aluminum shielding from holder</li> <li>2. Press button on microcontroller unit to reset counter and close circuit</li> </ol>	Radiation	Exempt quantity Pyrex beaker containment	None
<b>Shutdown Procedure</b>			
<ol style="list-style-type: none"> <li>1. Remove hydrogen containment vessel</li> </ol>	Hydrogen gas escaping while Hydrogen containment vessel is capped	Clamp Hydrogen containment vessel mouth closed before removing from nozzle on car body	None
<b>Cleanup / Waste Disposal</b>			
<ol style="list-style-type: none"> <li>1. Place <sup>137</sup>Cs source in lead containment tube and cover with lid</li> <li>2. Remove anaerobic stoppers from fuel cells and dispose of depleted rumen fluid in an appropriate compost pile/manure pit/biowaste disposal.</li> <li>3. Disinfect any surfaces that may have been exposed to rumen fluid using bleach</li> </ol>	Radiation Biological	Exempt radiation quantity Lead shielding Absence of pathogens Lab procedure	Safety glasses Close-toed shoes Long pants

## Equipment List

Please list every piece of equipment on the car. Please include all manufacturer's specification documents or specifications for custom-built components in the EDP Supplement document.

Number	Equipment	Manufacturer	Operating Limits: Temperature	Operating Limits: Pressure	Incompatible Materials?
1.	Aluminum Chassis	Previous UW Chem E Car Team	< 1220 °F	N/A	None
2.	K'nex axles, tires, and motor	K'nex corporation	Not listed	N/A	None
3.	22 gauge Appliance Wire	Carol	-4 °F to 221 °F	N/A	Sparks, H <sub>2</sub> O
4.	Geiger counter	Images Scientific Instruments	Not listed	N/A	Liquids
5.	PLA printed electronics housing	UW Coe Library Makerspace	<145 °F	N/A	None
6.	2x4 Wood Block	Truss Craft	N/A	N/A	Sparks
7.	5 x Horizon PEM Reversible Fuel Cells	Fuel Cell Store	Not listed	Not listed	Not listed
8.	Hydrogen Containment Vessel, Inverted Bell Vessel	Fuel Cell Store	Not listed	Not listed	Not Listed
9.	Gorilla Tape	Gorilla Glue Industries	-40 °F to 120 °F	N/A	None
10.	PVC 3/8" x Tubing	UW Chem Stockroom	< 200 °F	Joints at 1 psig	None
11.	Vacuum Connector Ts	Dorman	Not listed	Not listed	None
12.	Banana Plugs	Cal Test Electronics	Not listed	N/A	Sparks
13.	Lexel Silicon Sealant	Sashco corp	-18°C - 49°C	N/A	Strong oxidizing agents
14.	myRIO 1900	National Instruments	0°C - 40°C	N/A	Liquids

15.	Digilent MXP Bread Board	Diligent	N/A	N/A	Sparks, H <sub>2</sub> O
16.	SPDT Micromini 5V DC Relay	Radio Shack	-22 °F to 167 °F	N/A	Sparks, H <sub>2</sub> O
17.	9V Snap Connectors	Keystone Electronics	N/A	N/A	Only compatible with 9V batteries
18.	9V Battery	Duracell 9V Batteries	-4°F to 130°F (-20° C to 54° C)	N/A	Sparks, H <sub>2</sub> O,
19.	Aluminum Shield		<4,478 °C	N/A	None
20.	Canvas	Walmart	N/A	N/A	Sparks
21.	Snaps	K-Knife Company	N/A	N/A	None
22.	200 mL Pyrex Beaker no. 1040	Corning	<490 °C	N/A	None
23.	Water Bottle	Grainger	115-135 °C	N/A	None

## Discharged Hydrogen Calculations

If your car will include a small amount of hydrogen discharge, please use this space to provide calculations to prove to the reviewer that any discharged hydrogen is well below the Lower Flammable Limit (LFL)/Lower Explosive Limit (LEL) of hydrogen for the given volume of the reactor, chamber or fuel cell in which hydrogen is stored. If your car does not use hydrogen, then this section should be left blank.

A gas chromatography experiment run on the gas produced from the microbial electrolysis cells, gives a peak area of 515.31 V s for the peak corresponding to hydrogen. The calibration of this machine is given by the equation  $C \left[ \frac{\mu\text{mol}}{30 \mu\text{L}} \right] = 1.18734 \times 10^{-6} A [\text{V s}]$ , where  $C$  is the concentration of hydrogen, and  $A$  is the peak area. Substituting, we have  $C = 1.18734 \times 10^{-6} (515.31) = 6.12 \times 10^{-4} \frac{\mu\text{mol}}{30 \mu\text{L}}$ . Converting, that gives us  $C = 0.02 \times 10^{-6} \frac{\text{mol}}{\text{L}}$ . It is well established that 1 mole of gas at Standard Temperature and Pressure (STP) occupies approximately 24 L in volume. Taking that as a concentration,  $C_{air} = 0.04 \frac{\text{mol}}{\text{L}}$ . The lower flammability limit of hydrogen is 4% (CAMEO Chemicals), meaning that we must bring the hydrogen concentration below  $C_{max} = 1.63 \times 10^{-3} \frac{\text{mol}}{\text{L}}$ . Comparing, we find that  $0.02 \times 10^{-6} \frac{\text{mol}}{\text{L}} \ll 1.63 \times 10^{-3} \frac{\text{mol}}{\text{L}}$ , therefore  $C \ll C_{max}$  and the expected hydrogen concentration is well below the LFL.

## Pressure Calculations

For all cars with pressure greater than 1psig, please complete the following in this section. The textbook “Chemical Process Safety” by Crowl and Louvar can be used as reference. Please see Appendix A of the Safety Rules for full instructions on what is required for Pressure Testing. If your car does not generate pressure above 1 psig, you may leave this section blank.

:

- A quantitative design basis for pressure relieving load; N/A

- Sizing calculations for a pressure relief device; N/A

- Test procedure and results for a pressure relief. N/A

---

# APPENDIX 8.

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## AIChE EDP Supplement Pages

Product documentation, safety data sheets, management of change forms and any additional information required by AIChE for submission to the ChemE Car Contest

## AIChE National Chem-E Car Competition

### Engineering Documentation Package (EDP) Reviewer Checklist

Thank you for volunteering to review the Engineering Documentation packages this year. Please ensure you have a current copy of the 2019 safety rules, it has been updated. Please review the student team's engineering package which also contains the JSA. By following this checklist, you will ensure that each car entered into the competition is abiding by the safety rules set forth by the CHEM-E car rules committee. Please check the appropriate boxes or fill in comments where required. The review process will end with your submittal of this form to Tara Henriksen by the appropriate deadline. Please contact Tara Henriksen at 'vbritelite@hotmail.com' if you unable to assist. Thank you in advance for your participation.

University Name:	University of Wyoming
Vehicle Name:	<a href="#">The ChemE Car That Cud</a>
Reviewer Name:	Andy Moore
Reviewer e-mail:	<a href="mailto:andy.moore@windwardpllc.com">andy.moore@windwardpllc.com</a>
Faculty Supervisor:	David M. Bagley
Faculty Email:	<a href="mailto:bagley@uwyo.edu">bagley@uwyo.edu</a>
<b>Overall Comments</b> On the safety of this vehicle	<p>Novel idea. Clever.</p> <p>As the team included a hydrogen LEL calc, update the haz sheet by checking off C) flammable on pdf page 17.</p> <p>Good luck Team "Glowing Cud".</p>

### Vehicle Approval Statement

<b>Accepted</b>	<input checked="" type="checkbox"/>	I approve this vehicle for competition pending on site review.
<b>May Be Accepted</b>	<input type="checkbox"/>	I approve this vehicle for competition pending onsite review, providing that 1) the following design changes are made and documented: 2) the following EDP documentation changes are made:
<b>Not Accepted</b>	<input type="checkbox"/>	I do not approve this vehicle for competition.

Safety Rules Verification			
Certification		<input checked="" type="checkbox"/>	The certification package is signed by the Team's faculty advisor and/or consultant.
Safety Rules	Reviewer Initials	<b>asm</b>	I certify that I have read the latest version of the ChemE-Car Safety Rules and believe this car is in full compliance with these rules.
Signature of Reviewer			
Date		3/15/2019	

**ChemE-Car Engineering Design Package (EDP)**  
**Quality Assurance Evaluation**

Completed? Y/N or N/A	Reviewer Comments and Notes (Please comment on any deficiencies here)
<b>Design - Process Safety Information</b>	
<b>Hazards of Materials</b>	
y	Safety Data Sheets (SDS) for each reactant/product
y	Identified Personal Protection Equipment (PPE)
y	Chemical use and disposal management system detailed
<b>Process Technology</b>	
y	Summary describing the chemistry involved Includes references
y	If hydrogen is used, students are generating hydrogen <b>ONSITE</b> or <b>ONBOARD</b> the car, and below
y	Clear description and diagram of the car and how it works
y	Includes picture of the car after construction is completed
y	Syringes, etc. appear to be secure
y	Secondary containment appears to be adequate
<b>Equipment Design Basis</b>	
y	Tabulated and complete list of every piece in the car, including the operating T and P for each component. (Use vendor's design limits for purchased pieces. For custom pieces, use material properties.)
y	Specification sheets for purchased equipment from vendor (manufacturer)
<b>Pressure Relief Design Basis and Testing (if applicable)</b>	
n/a	Pressure vessel has certification from manufacturer or students have provided testing procedure and results of the testing per Appendix in the Safety Rules.
n/a	Properly designed, tested and installed pressure relieving device (see questions below)
n/a	Quantitative design basis calculations for the pressure relieving load requirements (students must explain how they determined the pressure relief requirements using calculations).
n/a	Sizing calculations for the pressure relief device that meets expected load (students must show calculations which demonstrate that the PRV area of orifice size is appropriate for the needed flowrate)
n/a	Test procedure and results confirming safe pressure relief
n/a	Maximum pressure in the car does not exceed 500 psig.



ChemE-Car Engineering Design Package (EDP) Quality Assurance Evaluation		
Completed? Y/N or N/A		Reviewer Comments and Notes (Please comment on any deficiencies here)
<b>Hazards Analysis</b>		
		Reviewer please list the hazards here:
y	Summary of the types of hazards inherent in the car's design: Flammable, Explosive, Toxic, Reactive, Pressure, Temperature, Electrical, Mechanical, or Oxygen	While H2 LEL calcs were included, H2 wasn't listed as a flammable hazard.
y	Completed JSA form	
y	Proper safeguard design and safety measures taken to ensure that hazards are prevented/contained	
n	Are any disallowed activities or vehicles present?	
<b>Design and Construction Change Management</b>		
y	Includes adequate change management procedure (MOC) that records changes made to the original design (Note, this may simply be printed from the AIChE website)	
<b>Car Experimentation Area Floor Plan</b>		
	Identifies exits	
	Identified emergency equipment in area, such as fire extinguishers	
<b>Operating Procedures</b>		
y	Detailed and accurate operating procedures	
y	If applicable, hazardous chemical handling and waste disposal procedures	
y	Operating procedures for between runs clean up and final clean up phase of competition.	
<b>Certification</b>		
y	EDP Certification Page, signed by Faculty Supervisor and/or Consultant	
y	Certification sheet indicates students have operated the vehicle for at least 10 hrs.	

## **Car Body**

No manufacturer's specifications available.

**K'NEX**  
BUILDING SYSTEM



**30**  
**MODEL**  
**MULTI-MOTOR**  
**CASE SET**



**8+**



**WARNING:**

CHOKING HAZARD - Small parts.  
Not for children under 3 years.



**AVERTISSEMENT:**

DANGER D'ÉTOUFFEMENT - Pièces de petite taille.  
Ne pas donner aux enfants de moins de 3 ans.

**338 pcs/pzs/pzas**

13074/22806

2

3



# WHAT'S INSIDE?

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Manta. . . . .	65
Space Transporter . . . . .	65
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3 Wheeler. . . . .	66
Kart Racer . . . . .	66
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Boat Ride . . . . .	67
Swing Ride . . . . .	67

# IMPORTANT STUFF FOR PARENTS & KIDS

Keep these instructions in a handy location. They contain important safety information.

Read all warnings and instructions before you start to build and operate the model.

**⚠ WARNING: CHOKING HAZARD -** Small parts. Not for Children under 3 years.

**⚠ CAUTION:** Keep hands, face, hair and clothing away from all moving parts.

**⚠ CAUTION:** Hair entanglement may result if hair comes in contact with moving parts of motor. Adult supervision is required.

**⚠ CAUTION:** Rubber Bands can cause injury from snap-back, breaking, or loss of control. While assembling model shown in instructions, hold Rubber Band tightly, and do not overstretch. Use Rubber Band only as shown in these instructions. **DO NOT USE FRAYED OR TORN RUBBER BANDS**

**⚠ CAUTION:** Keep Rubber Band away from face and eyes. Do not launch in the direction of people, animals, or walls; you could cause injury or damage. Do not overwind.



## BATTERY INFORMATION

### ⚠ CAUTION:

- Be sure to insert the batteries correctly and always follow the toy and battery manufacturers' instructions.
- Do not mix old and new batteries or alkaline, standard (carbon-zinc) or rechargeable (nickel-cadmium) batteries. Only batteries of the same or equivalent type recommended should be used.
- Always remove weak or dead batteries from the product; do not short-circuit supply terminals.
- Insert batteries with correct polarity (+/-) as shown.

### Important Tips

- Alkaline batteries are recommended.
- Rechargeable batteries are not recommended.
- Remove rechargeable batteries from toy before charging; they must be charged only under adult supervision.
- Non-rechargeable batteries must not be recharged.
- Keep components free of dust; do not immerse or use in water.
- Do not dispose of batteries in a fire; they could leak or explode and cause injury.
- Remove all batteries if the toy will not be used for a long period of time.
- Do not put Rods smaller than 2 inches in any openings of the motor; they will damage the motor, and cannot be removed.



### How to Insert and Remove Batteries

Use a small Phillips head screwdriver to loosen the screw. Insert 2 fresh AA batteries (LR6) into the compartment with the correct polarity (+/-) as shown here.



### MicroPower™ Motor

Toy will go in the direction of the arrow on top of the Motor. Wind until you hear clicking. Then release. Do not over wind.

## PARTS LIST

Before you start building, be sure to compare the parts in your set with the parts listed here. If anything is missing, check out the back cover of this instructions booklet for how to contact us. We're here to help!







**US 1-800-KID-KNEX USA/Canada only (English only)**

**GB 00800-22427276 UK/Ireland only**

**Customer Service outside the USA, CAN, GBR  
please contact local distributor.  
Distributor information can be found at:  
<http://www.knex.com/contact/international.php>**



**US Consumer Services  
K'NEX Industries, Inc.  
P.O. Box 700  
Hatfield, PA 19440-0700**



**GB K'NEX  
Newport Consumer Services  
Hasbro UK Ltd., Caswell Way  
Newport, Gwent NP9 0YH**



**email@knex.com**



Product and colors may vary.  
Models can be built one at a time.  
Le produit et les couleurs peuvent varier.  
La plupart des modèles ne peuvent être construits que un à un.  
El producto y los colores podrán variar.  
La mayoría de los modelos se puede construir uno a la vez.

Conforms to the Requirements of  
ASTM Standard Consumer  
Safety Specification on Toy Safety, F963-03.  
Conforme aux spécifications de sécurité  
du consommateur sur la sécurité des jouets  
de la norme ASTM F963-03.  
Cumple con los requisitos de la Norma F963-03.  
[Especificación para consumidores sobre la  
seguridad de juguetes], de la ASTM.

Manufactured under U.S. Patents/Fabriqu  
sous brevets américains 5,061,219;  
5,137,486; 5,199,919; 5,346,420; 5,350,331;  
5,368,514; 5,421,762; 5,423,707; 5,427,559;  
D383,509; D388,475; D389,203; D391,843;  
D392,555; D403,722; 5,913,706; 6,089,941.  
Other U.S. and foreign patents pending.  
Autres brevets américains  
et étrangers en instance.



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P.O. Box 700  
Hatfield, PA 19440-0700

406538.11-V1-4

Part Number: C2016A

Revision Level: 02

Date: March 8, 2006

---

## 1C 22 7/30 TC PVC INS

## HOOK-UP WIRE

---

### A. CONSTRUCTION

### DIAMETERS

- |                  |   |                   |
|------------------|---|-------------------|
| 1) CONDUCTOR:    | #22 AWG 7/30 Tinned Copper  | 0.030" nom.       |
| 2) INSULATION:   | 0.016" Wall Polyvinyl Chloride  | 0.062" +/- 0.003" |
| 3) PRINT LEGEND: | <b><i>CAROL A 22 AWG RU AWM 80C VW-1 E18621-8 --- CSA LL69381 TR64 90C --</i></b> |                   |

### B. INDUSTRY APPROVALS

UL Subject 758

AWM Style 1007, 1569

CSA International

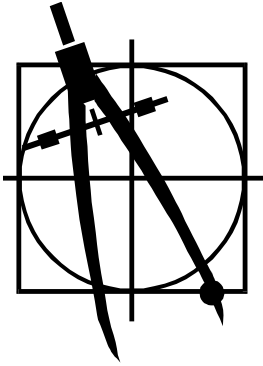
Type TR64

### C. ELECTRICAL PROPERTIES

- |                                      |                                |
|--------------------------------------|--------------------------------|
| 1) TEMPERATURE:                      | 80 C                           |
| 2) SUGGESTED WORKING VOLTAGE (Vrms): | 300Vrms                        |
| 3) CONDUCTOR D.C. RESISTANCE:        | 16.6 Ohms/1000 ft. nom. @ 20 C |

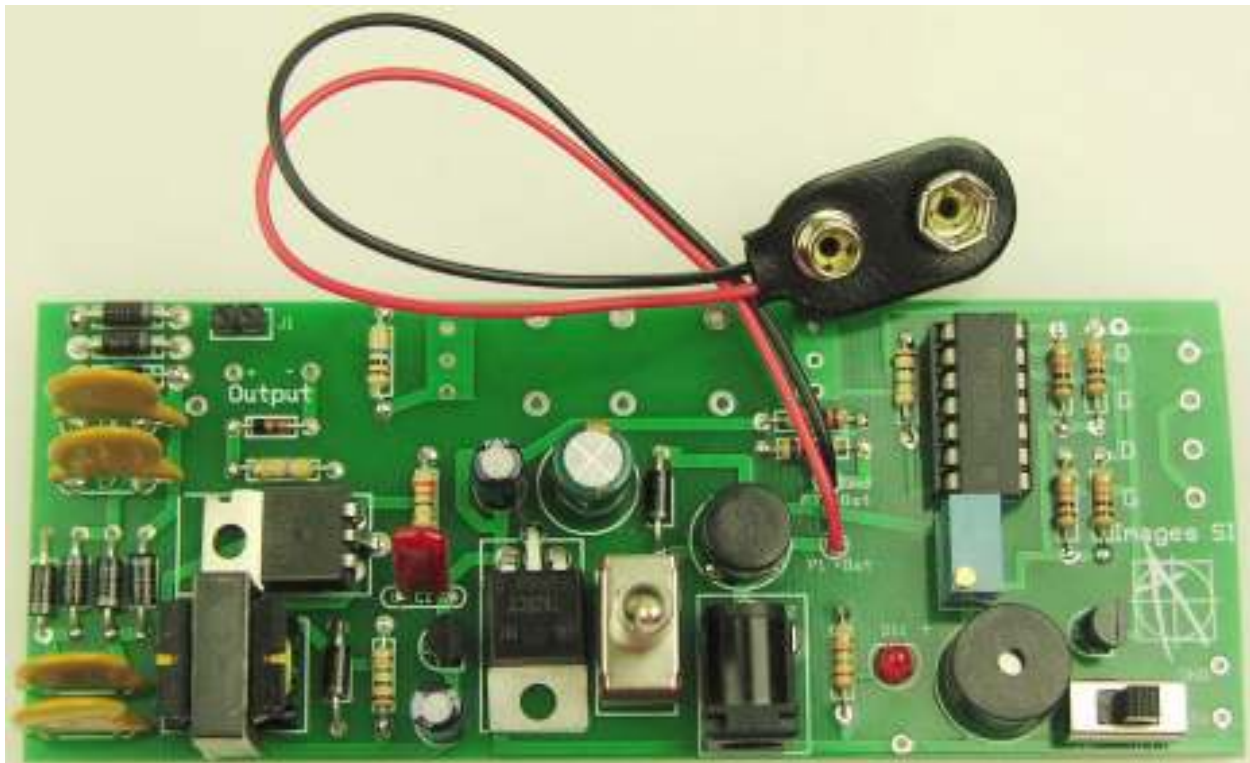
Note: Data are subject to change without notice. Contact your Customer Service representative for latest information.





Images Scientific Instruments, Inc.  
109 Woods of Arden Road  
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718.966.3695 Fax  
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## **GCK-02 Geiger Counter Kit Manual and Assembly Guide**





This kit can utilize a variety of GM tubes, so depending upon a GM tube's availability you can choose one that is readily available and in your price range.

Once assembled, this Geiger counter outputs audible click and will blink an LED with each radioactive particle it detects. In addition, it has two digital outputs that may be connected to a number of accessory instruments; a data logger, Digital Meter adaptor that outputs an approximate radiation level, RS-232 adaptor to plot radioactivity on a PC, and true random number generator, in addition to an analog / digital meter adaptor.

### What is Radioactivity

Radioactivity is the spontaneous emission of energy from the nucleus of certain atoms. The most familiar radioactive material is uranium.

There are three forms of energy associated with radioactivity; alpha, beta and gamma radiation. The classifications were originally determined according to the penetrating power of the radiation, see figure 1. Depending upon your GM tube selection our Geiger counter can detect the three types of radiation; alpha, beta and gamma radiation.

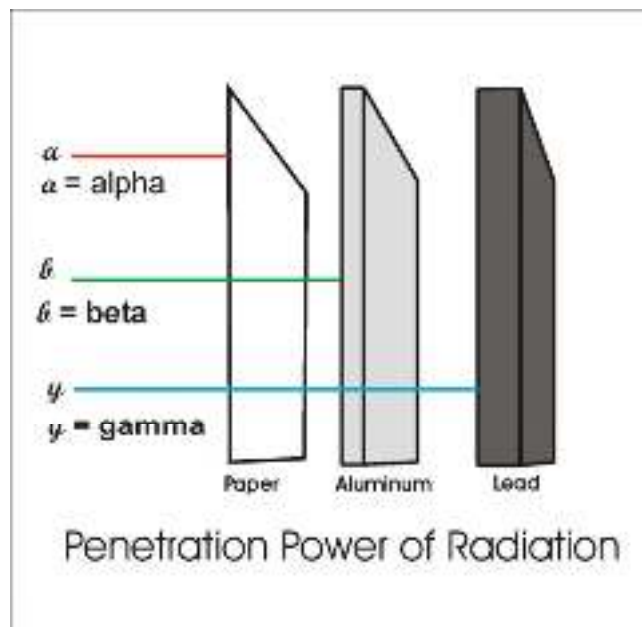


Figure 1

Alpha rays are the nuclei of helium atoms, two protons and two neutrons bound together. Alpha rays have a net positive charge. Alpha particles have a weak penetrating ability, a couple of inches of air or a few sheets of paper can effectively block them.

Beta rays were found to be electrons, identical to the electrons found in atoms. Beta rays have a net negative charge. Beta rays have a greater penetrating power than Alpha rays and can penetrate 3mm of aluminum.

Gamma rays are high-energy photons. This has the greatest penetrating power being able to pass through several centimeters of lead and still be detected on the other side. Thick lead is needed to attenuate gamma radiation.

## Geiger Mueller Tube

Geiger Mueller tubes are simple devices that detect and measure the intensity of radioactivity. The original design by H. Geiger and E.W. Mueller in 1928 hasn't changed very much. The basic sensor functioning remains the same.

A cutaway drawing of a typical Geiger Mueller (GM) tube is shown in figure 2. The wall of the GM tube is a thin metal (cathode) cylinder surrounding a center electrode (anode). The metal wall of the GM tube serves as the cathode of the GM Tube. The front of the tube is a thin Mica window sealed to the metal cylinder. The thin mica window allows the passage and detection of the weak penetrating alpha particles. The GM tube is first evacuated, then filled with Neon, Argon plus a Halogen gas.

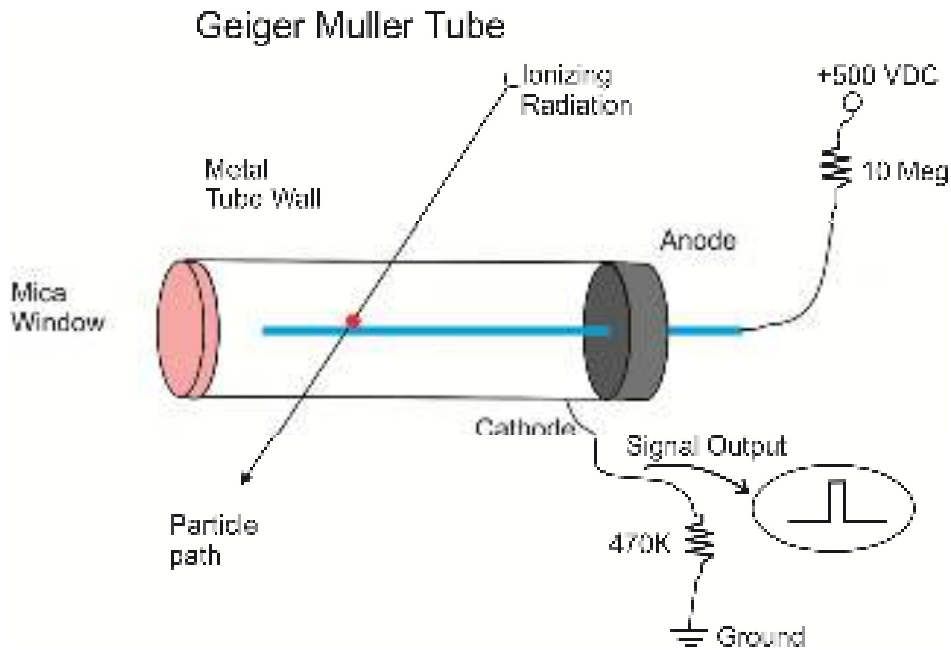


Figure 2

Our GM tube is put into an initial state (ready to detect a radioactive particle), by applying + 500-volt potential to the anode (center electrode) through a ten mega ohm current limiting resistor. A 470K-ohm resistor is connected to the metal wall cathode of the tube and to ground. The top of the 470K resistor is where we see our pulse signal whenever a radioactive particle is detected.

In its initial state the GM tube has a very high resistance. However, when a radioactive particle passes through the GM tube, it ionizes the gas molecules in its path and creates a momentary conductive path in the gas. This is analogous to the vapor trail left in a cloud chamber by a particle. In the GM tube, the electron liberated from the atom by the particle and the positive ionized atom both move rapidly towards the high potential electrodes of the GM tube. In doing so, they collide with and ionize other gas atoms, creating a momentary avalanche of ionized gas molecules. And these ionized molecules create a small conduction path allowing a momentary pulse of electric current to pass through the tube allowing us to detect the particle.

This momentary pulse of current appears as a small voltage pulse across the 470 K ohm resistor. The halogen gas quickly quenches the ionization and the GM tube returns to its high resistance state, ready to detect more radioactivity.

## Dead Time

For the short amount of time the GM tube is detecting one particle, if another radioactive particle enters the tube it will not be detected. This is called dead time. The maximum dead time for the LND 712 GM tube is 90 microseconds (or .00009 seconds). There is a mathematical formula for adjusting a Geiger counter read out to compensate for the GM tube's dead time. Different GM tubes have different dead times.

## Count Rate vs. Dose Rate

Each output pulse from the GM tube is a count. The counts per second give an approximation of the strength of the radiation field. Typically a GM tube is calibrated using either a cesium-137 or cobalt-60 radiation source. The chart is shown in figure 3 is a typical response curve for a generic GM tube. Each GM tube will have its own response curve to radiation. For many of the GM tubes available on Ebay, the response curve is not available.

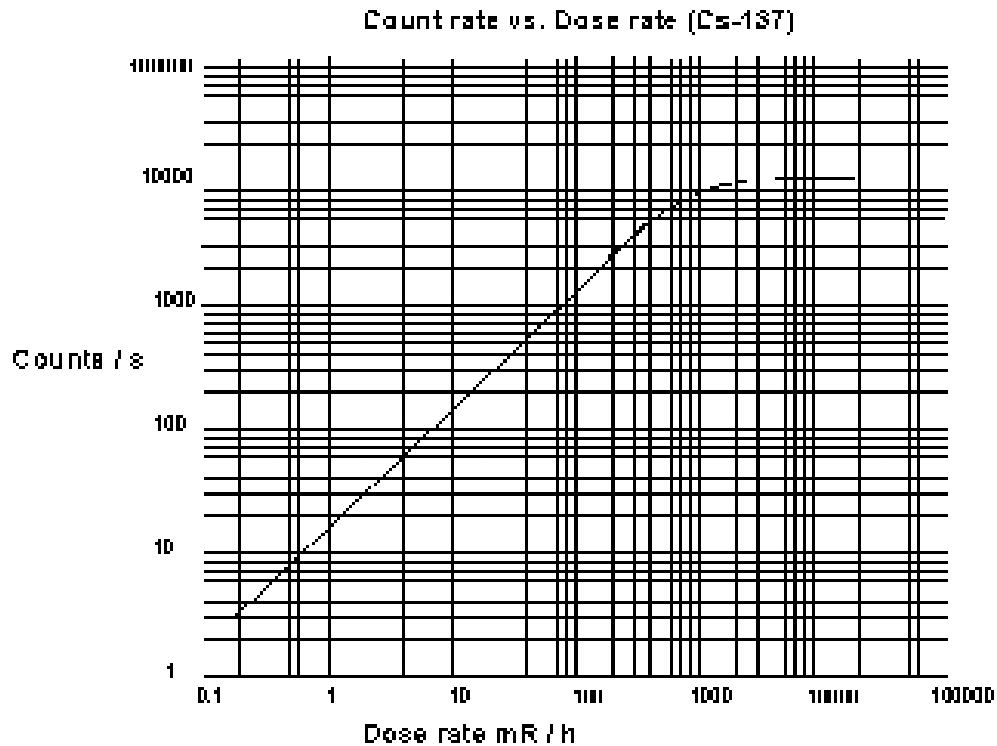


Figure 3

## Measurement of Radiation

There are a few scales that one can use to measure radiation. Depending upon your application, one scale may be better than the others.

### Radiation Measurements

**Roentgen:** Is the measurement of energy produced by Gamma or X-Ray radiation in a cubic centimeter of air. It is abbreviated with the capital "R". One milliroentgen, abbreviated "mR", is one-thousandth of a roentgen. One microroentgen, abbreviated "uR", is one-millionth of a roentgen.

**RAD:** Radiation Absorbed Dose. Original measurement unit for expressing the absorption of all types of ionizing radiation (alpha, beta, gamma, neutrons, etc.) into any medium. One rad is equivalent to the absorption of 100 ergs of energy per gram of absorbing tissue.

**REM:** Roentgen Equivalent Man is a measurement that correlates the dose of any radiation to the biological effect of that radiation. Since not all radiation has the same biological effect, the dosage is multiplied by a "quality factor" (Q). For example, a person receiving a dosage of gamma radiation will suffer much less damage than a person receiving the same dosage from alpha particles, by a factor of three. So alpha particles will cause three times more damage than gamma rays. Therefore, alpha radiation has a quality factor of three. Following is the Q factor for a few radiation types.

Radiation:	Quality Factor (Q)
Beta, Gamma and X-rays	1
Thermal Neutrons	3
Fast n, a, and protons	10
Heavy and recoil nuclei	20

The difference between the RAD and REM is that the RAD is a measurement of the radiation absorbed by the material or tissue. The REM is a measurement of the biological effect of that absorbed radiation.

For general purposes most physicists agree that the Roentgen, Rad and Rem may be considered equivalent.

The Curie is a unit of radioactivity, its symbol (Ci). It is defined by the amount radioactive decays per second.  
 $1\text{Ci} = 3.7 \times 10^{10}$  decays per second.

When you purchase a radioactive isotope source, it will be rated in microcuries (uCi) (one millionth of a Curie).

### System International (SI) of Units

The System International of unit for radiation measurements is now the official system of measurements. This system uses the "gray" (Gy) and "Sivert" (Sv) for Absorbed dose and equivalent dose, respectively.

The conversion from one system to another is simple:

1 Sv	= 100 rem	1 rem = .01 Sv
1 mSv	= 100 mR (mrem)	1 mR = .01 mSv
1 Gy	= 100 rad	1 rad = .01 Gy
1mGy	= 100 mrad	1 mrad = .01 mGy

The SI derivative of the curie is the becquerel (Bq) (pronounced: 'be-kə-rel) which equals one decay per second.

### How Much Radiation is Safe?

In the United States, the U.S. Nuclear Regulatory Commission (NRC) determines what radiation exposure level is considered safe. Occupational exposure for worker is limited to 5000 mrem per year. For the general population, the exposure is 500 mrem above background radiation in any one year. However for long term, multi-year exposure, 100 mrem above background radiation is the limit set per year.

Let's extrapolate the 100 mrem number to an hourly radiation exposure rate. There are 365 days/yr x 24 hr/day equals 8760 hours. Divide 100 mrem by 8760 hours equals .0114 mrem/hr or 11.4/hr microrem. This is an extremely low radiation level. The background radiation in my lab hovers around 32 uR/hr. Am I in trouble? No. Typically, background radiation in the United States averages 300 mrem/yr, or 34 microrem/hr. The NRC specifications is for radiation above this 34 urem/hr background radiation.

Notice that my lab readings are in microrad (uR/hr) and the exposure limit is given in microrem (urem/hr). I do not know what type of radiation (a, b or y) the Geiger counter is reading in my lab at any particular instant, so I do not know the Q factor of the radiation and therefore cannot calculate the mrem. However, for general purposes I consider them the one and the same. The digital Geiger counters I use are calibrated using a Cs-137 radioactive source. Therefore the highest accuracy in reading radiation levels will be from Cs-137 sources.

### Common Radiation Exposure (General Population)

Exposure Source	Dose (conventional)	Dose (SI)
Flight from LA to NY	1.5 mrem	.015 mSv
Dental X-ray	9 mrem	.09 mSv
Chest X-ray	10 mrem	0.1 mSv
Mammogram	70 mrem	0.7 mSv
Background Radiation	620 mrem/year	6.2 mSv/year

Background radiation consists of three sources; Cosmic radiation from the sun and stars. Terrestrial radiation from low levels of uranium, thorium, and their decay products in the soil, air and water. Internal radiation from radioactive potassium-40, carbon-14, lead-210, and other isotopes found in our bodies.

### Testing for Radioactive Contamination

For this test to be as sensitive as possible, it is recommended that the GM tube be sensitive to alpha, beta and gamma radiation.

Geiger counters can only test for gross radioactive contamination levels that will show up above background radiation levels. Low level radioactive contamination may be effectively hidden within the natural "noise" of background radiation and not discernable using a Geiger counter. Therefore, for low level radioactive contamination Geiger counters are not the proper test instruments. With this disclaimer in place, this is the procedure to test for radioactive contamination that presents an increase in the background radiation. Step one; first establish the background radiation level.

To establish background radioactivity level, record the pulses (Counts) received per minute (CPM). The greater number of minutes you count, the more accurate your background radiation reading will be. Average the CPM reading to determine an approximate background radiation level for your area. The highest and lowest CPM count will establish your minimum and maximum CPM. These numbers will establish a baseline so that you will be able to determine if the background radiation has changed, or to detect trace amounts of radioactive materials.

If you look at the data I obtained from the Data Logger discussed later, in the Excel spreadsheet my average CPM reading, based on 298 samples, was 16 CPM. The Minimum CPM was 6 and the Maximum CPM 28.

To run a test position the probe (or Geiger counter) very close to the top surface of the material you are testing, and run the counter recording the CPM output. The longer the run obtaining CPM data, the more accurate the results.

Compare the radiation output of your sample under test to your establish background radiation.

**Images does not make any warranties (express or implied) about the radiation information provided here for your use. All information provided should be considered experimental. Safety and health issues and concerns involving radioactive contamination should be addressed, confirmed and verified with local and national government organizations or recognized experts in this field.**

## Geiger Counter Schematic Caution \* High Voltage \* Caution

**While the Geiger counter is on (powered), the bare PC board contains exposed high voltage components and pads. Even when the circuit is turned off (power is removed) the capacitors still may hold a high voltage charge. A project box or case is recommended and available for separate purchase based on the option chosen for your kit.**

The circuit is shown in figure 4. The HV section of the circuit is built around a single transistorized (TIP3055) ringing choke converter that has been around for years. This particular derivative of the circuit was designed by Sam Evans to minimize current draw. The important element in this circuit is the transformer.

In this configuration, the primary winding of the transformer and the feedback winding of the transformer are arranged so that the circuit begins a sustaining oscillation when power is applied. If you checked the output of the oscillator you would find the waveform's duty cycle is symmetrical.

The primary oscillation amplitude is around 6V at 14.1kHz. This gets amplified with the large step-up ratio of the transformer and we obtain about  $325V_{(p-p)}$  across the secondary. The current consumption is about 5ma. A simple voltage multiplier is used to boost up this voltage in steps to give a final DC of about 600V DC.

The high voltage output from this stage is regulated by Zener diodes. Here the user can decide which Zener diode regulators to use to vary the regulated DC output. There are three Zener diode positions on the PC board, D8, D9 and D10. If one uses a 200V Zener in each position the regulated output is 600 volts. Using a 100 volt Zener in each position the regulated output is 300 volts. Using (2) 200V Zeners and (1) 100 volt Zener provides 500 VDC regulated output.

In the latest revision of the PC Board, there is a jumper, J1, that shorts out the D8 Zener. By putting 200 volt Zener diodes in the D9 and D10 position and a 100 volt Zener in the D8 position you can change the regulated output to the GM tube from 500 VDC to 400 VDC by adding a jumper.

So it's easy to vary the regulated output from 300 to 600 VDC depending upon the voltage required of their GM tube.

Assuming a 500 VDC output and a LND712 GM tube the 500-volt regulated output is fed to the anode of the GM tube through a current limiting 10 mega-ohm resistor R5. The 10 mega-ohm resistor limits the current through the GM tube and helps quench the avalanched ionization when a radioactive particle is detected.

The cathode of the tube is connected to a 1 Meg potentiometer and a 100K resistor. Each time a particle is detected a voltage pulse is generated across this resistance. The pulse is fed from the wiper of the potentiometer to the inverting input to a 339 comparator.

The comparator cleans up the pulse and down streams it to the three other comparators. The output of the second comparator is fed to the base of a 2N3904 transistor. The transistor powers an LED and speaker so that each time a particle is detected the LED blinks and the speaker clicks.

The other comparator outputs are available for use by the user via Screw terminals on the edge of the board.

Alternative Audio Output: To create a more pronounced click you can use the alternative audio output section. The pulse signal from the comparator is a trigger to the 555 Timer. The timer is set up in monostable mode that





## Construction

**Caution \* High Voltage \* Caution**

While the Geiger counter is on (powered), the bare PC board contains exposed high voltage components and pads. Even when the circuit is turned off (power is removed) the capacitors still may hold a high voltage charge. A project box or case is recommended and available for separate purchase based on the option chosen for your kit.

The PCB for this kit is shown in figure 5.

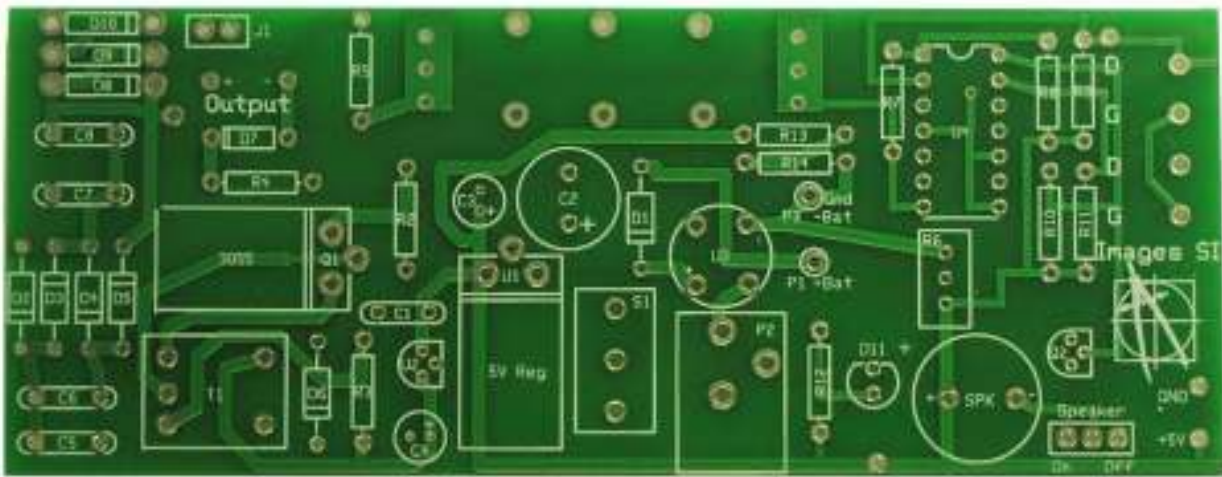


Figure 5

When using the PC board its merely a matter of mounting and soldering the components in their proper position. All the parts are outlined on the top silk screen, see figure 5.

Begin by mounting and soldering all the resistors, see figure 6.

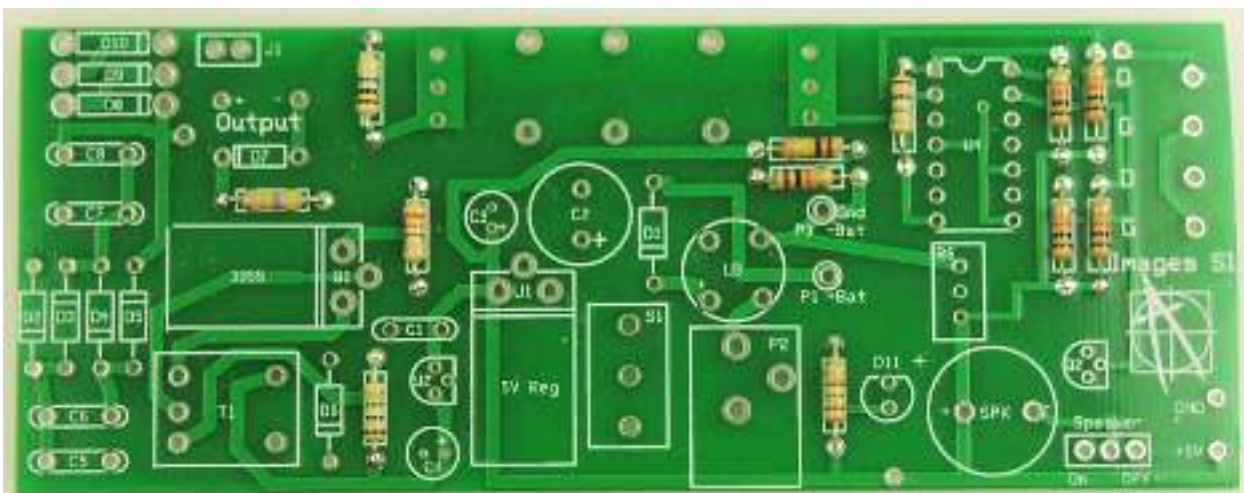


Figure 6

R2 - 33 ohm (color code - orange, orange, black, gold),  
R3 and R7 - 1 mega-ohm (color code - brown, black, green, gold),  
\*R4 - 470 K-ohm (color code - yellow, purple, yellow, gold),  
\*R5 - 10 mega-ohm (color code brown, black, blue, gold),  
R8-R11 and R14 - 10K-ohm (color code - brown, black, orange, gold),  
R12 - 100 ohms (color code - brown, black, brown, gold)  
R13 - 100 K-ohm (color code - brown, black, yellow, gold)

\*These resistor values will change depending upon the specific GM tube used. Default values are for the LND712 GM Tube.

### Customizing circuit for GM Tube.

The two resistors R4 and R5 need to be matched to your GM tube also. R5 is the anode resistor. The anode resistor prevents too much current from passing through the tube when the tube detects a radioactive particle. This resistor can vary between 2.2 mega-ohms and 10 mega-ohms for different GM tubes. You need to read the specifications on your particular tube. The Cathode resistor is R4 and may vary between 47 K ohm to 1 mega-ohms for different GM tubes. The voltage pulse across this resistor is fed to the comparator.

### Zener Diodes

Mount and solder diodes D1 through to D11. Make sure to orientate the line on the diodes with the line on the silkscreen diode drawing on the printed circuit board.

D1, D2, D3, D4, D5, and D6 - 1N4007

D7 - 5.1V Zener

D8 - 100V Zener

D9 and D10 - 200V Zener (\* See text)

D11 - LED

The longer lead on the LED (D11) is the positive lead. Make sure the positive lead is inserted into the pad toward the bottom of the PC board (on the round side of the silkscreen LED outline). Next mount and solder the 14 pin IC socket, see figure 7.

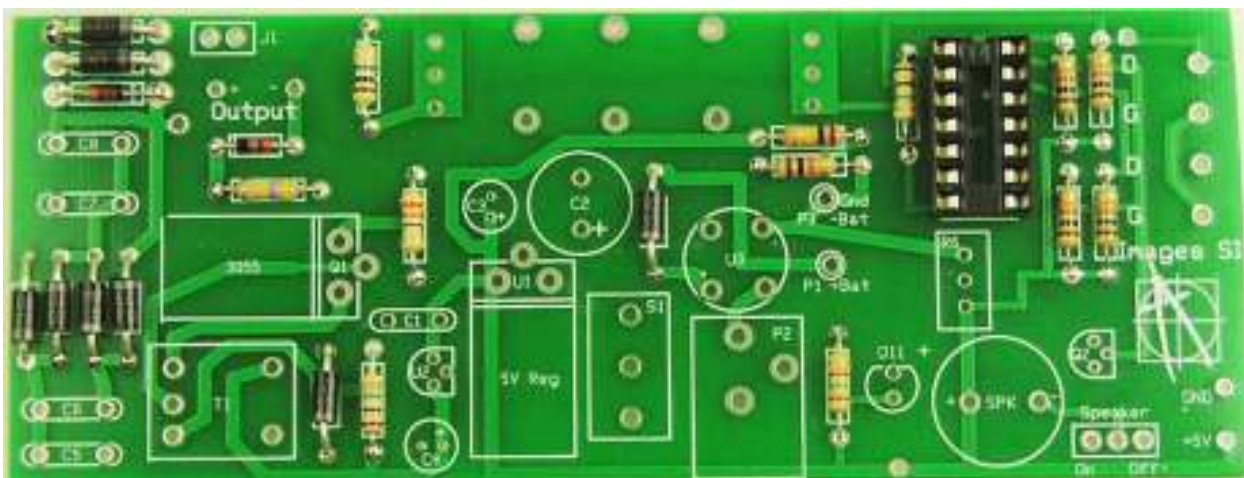


Figure 7

In addition to adjusting the resistors to the GM tube, you can also adjust the voltage to the GM tube. Depending upon the Zener diodes used, you can vary the voltage between 400 and 600 volts. The Zener diodes (D8, D9 and D10) to provide the regulation of the voltage delivered to the GM Tube.

The Zener diodes provided with the kit are D8 - 100 volts, D9 and D10 - 200 volts. With this diode set you can vary the voltage to either 400 volts or 500 volts to the GM tube. Keeping jumper J1 open will provide 500 VDC to the GM tube. Shorting jumper J1, shorts out diode D8 and provides 400 VDC to the GM tube.

If you required 600 VDC, diodes D8 to D10 ought to be made 200 Zener diodes. Keeping jumper J1 open provides 500 VDC to the GM tube. Shorting jumper J1, shorts out diode D8 and provides 400 VDC to the GM tube.

Next, install the regulator 7805 and the 3055 (or H1061) transistor. Insert components on the PC board and bend them into place BEFORE soldering, see figure 8. Mount and solder capacitors:

C1 - 0.1 $\mu$ F

C2 - 330 $\mu$ F-16V, (can vary between 220uf and 1000uf)

C3 and C4 - 10 $\mu$ F-16V,

C5, C6, C7 and C8 - 0.01 $\mu$ F - 1KV.

Mount and solder the mini-step-up transformer T1.

Mount and solder the 14 pin IC socket U4.



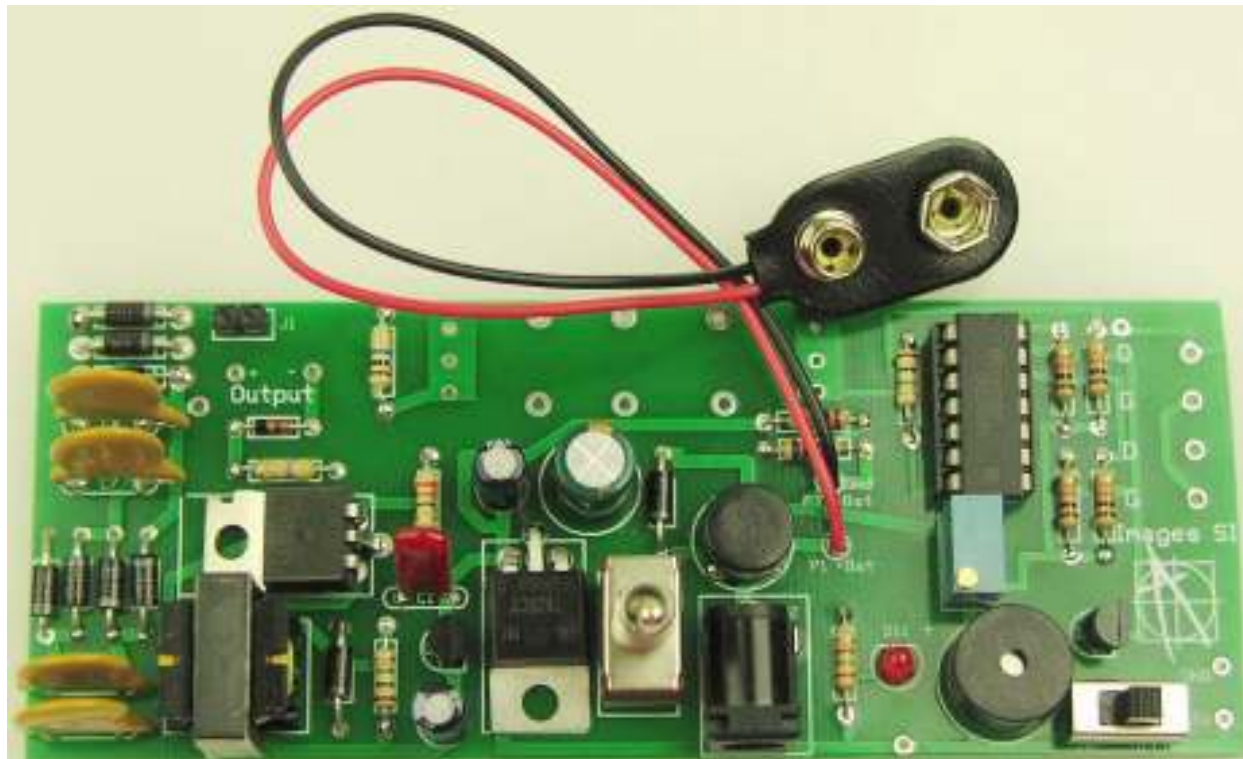
**Figure 8**

### **Finishing Board Construction**

Mount and solder U2 and Q2. Making sure their profile matches the silk screen outline of these parts before soldering. Next mount and solder the bridge rectifier U3. Align the positive terminal of the bridge rectifier with the + pad on the PC board. Mount and solder the P2 external power supply connector. Mount and solder S1 toggle switch. Mount and solder on-off slide switch for the speaker. Next mount and solder the piezoelectric speaker. The long lead on the speaker is positive and should be inserted into the + pad on the PC board. Mount and solder the 1-Mega-ohm potentiometer in the R6 position on the PC board. Next solder the 9V battery clip to



the PC board. The red wire is soldered to the P1 + Bat pad. The black wire is soldered to P3 -Bat pad. Finish the board by mounting and soldering the two pin header in the J1 position. Your board should appear as in figure 9.



**Figure 9**

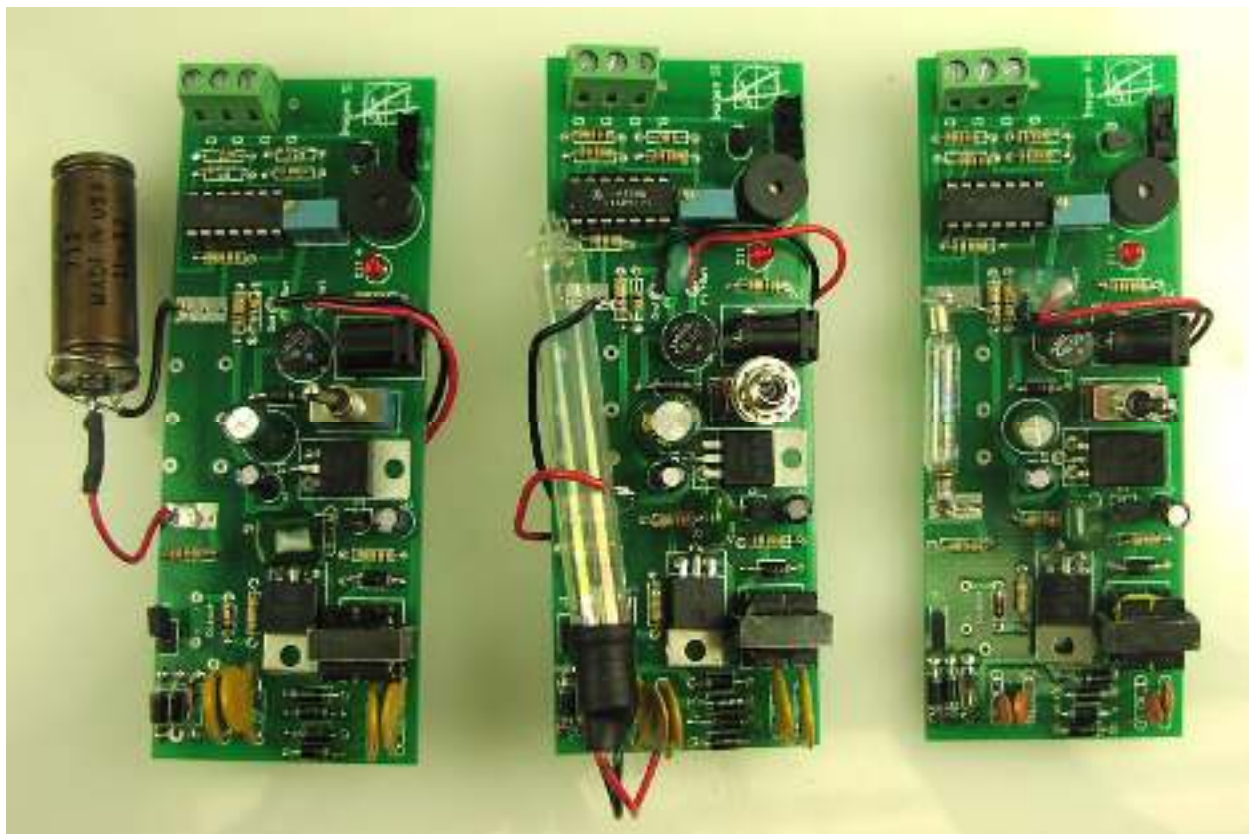
Insert the LM339 into the 14 pin socket., see figure 10. Align the notch on IC as shown in the figure 10.



**Figure 10**

## Attaching GM Tube(s)

With the board completed its time to attach the GM tube. The Geiger Muller tubes have two leads. For the LND 712 the lead connected to the metal sides of the tube is the ground. This is soldered to the (-) GM terminal on the PC board, see figure 11, left circuit. The center terminal of the GM tube has a removable solder lead. Remove the lead, solder 1.5" of wire to and. Reattach the lead to the center terminal of the GM tube. Take the opposite end of the wire and solder to the (+) GM terminal on the PC board.



**Figure 11**

The 712 Geiger Mueller tube's front mica window is delicate and should be protected by a screen. An open screen will protect the tube and at the same time allow the detection of alpha particles to pass through the front mica window.

The large and small glass GM tube in center position in figure 11 requires an anode resistor (R5) of 3.3 mega ohms and a cathode resistor (R4) of 470K ohms. The regulated voltage required for these tubes is 400 volts DC. You need to adjust the zener diodes in the regulator section to provide this voltage, by shorting the jumper J1.

The small GM tube, the right hand circuit in figure 1, may be mounted to the PC board and strapped down using a few pieces of scrap wire. After securing with a wire a small amount of glue or epoxy can be dabbed on the wire tube assembly for added support. Each end of the GM tube has a wire soldered to its end and the wire soldered into one of the side holes.

In my tests, the larger of the glass GM tube is more sensitive to gamma radiation than the smaller glass GM tube due to its greater detection volume and area.

## **Radioactive Sources**

Uranium ore is available from a number of sources, including e-bay. See suppliers list.

A more reliable source is to purchase a radioactive source. Small amounts of radioactive materials are available for sale encased in 1 inch diameter by ¼" thick plastic disks. The disks are available to the general public license exempt. This material outputs radiation in the micro-Curie range and has been deemed by the U.S. Federal government to be license free and safe.

The cesium-137 is a good gamma ray source. The cesium 137 has a half-life of 30 years.

### **Adjusting sensitivity of the Geiger counter- Check Out**

You will need to adjust the sensitivity of the Geiger counter. This is accomplished using potentiometer R6. Step one, turn on the Geiger counter. Step two, make sure the speaker switch is turned on. Step three, if you have a radiation source bring it very close to the GM tube. Step four, adjust R6 until you hear clicking and see the LED blink. Each radioactive particle detected will cause the Geiger counter to click and flash the LED. Depending upon the sensitivity of your GM tube, each click represents the detection of one of the radioactive rays; alpha, beta or gamma.

If you do not have a radioactive source background radiation, from natural sources on earth and cosmic rays will cause the Geiger counter to click. In my corner of the world, I have a background radiation that triggers the counter on average 16 Counts Per Minute (CPM). Adjust R6 until you hear approximately 16 counts per minute. While the average CPM in my area is 16, the actual counts vary between a min count of 6 CPM and a maximum of 28 CMP.

The clicking can get annoying when performing some nuclear experiments so an on-off speaker switch is available to turn off the speaker.

### **ACCESSORIES:**

In this section I will look at the accessories available for use with this Geiger Counter.

#### **Data Loggers - Digital Output**

This Geiger Counter has two digital outputs that output a +3-5V pulse with each detection of a radioactive particle.

#### **Analog /Digital Meter**

An electronic analog/ digital meter adds versatility to the Geiger Counter device by providing a visual indication of the intensity of the radiation field.

#### **Calibration of Geiger Counter using Analog/Digital Meter**

We can use a simple procedure to get a ball park calibration for the electronic Analog/Digital meter. The difficulty in calibrating the meter to any Geiger counter is difficult because of the variables in play. The GM tube's response can vary +/- 20 %. The strength of the uncalibrated radioisotope source can vary +/- 20% from its rated value. In addition to variance in our electronic components. All these factors affect accuracy. With this

being said, we can check the ball park accuracy of our meter. If your meter is adjustable, you can use the information to better approximate the radiation levels.

This calibration procedure uses a 10 uCi CS-137 source, see parts list. The source is held at specific distances from the GM tube for each range and the approximate radiation value is given in the chart below.

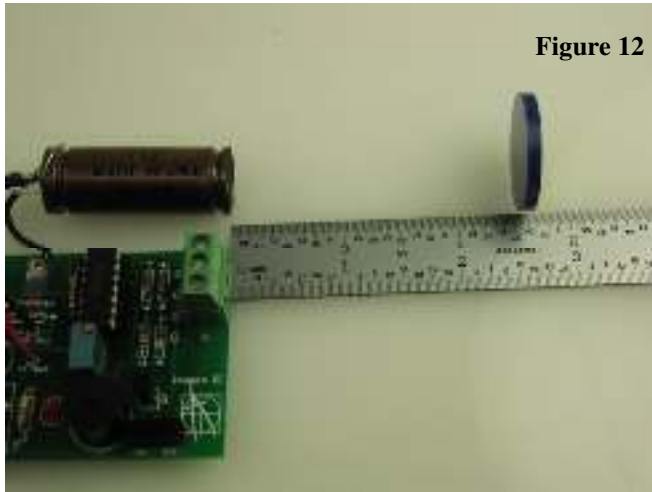


Figure 12

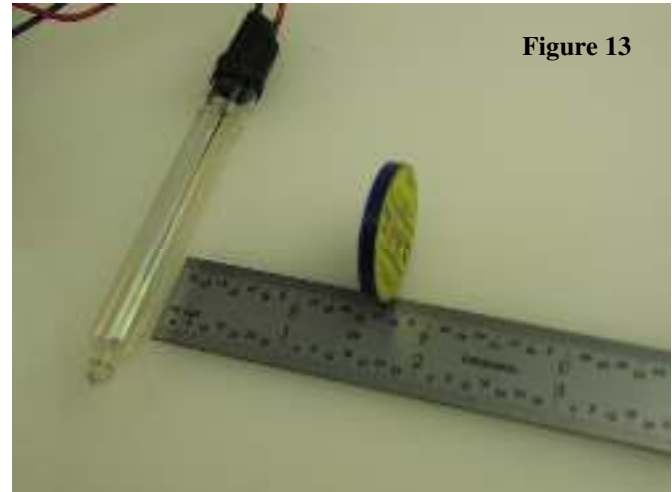


Figure 13

GM Tube	GMT-01 (LND712)	GMT-02	GMT-06
0-1 mR/hr	6"	6.5"	0.5"
0-10 mR/hr	2.5"	1.6"	0.25"
0-100 mR/hr*	0.5"	0.25"	0.0"

The procedure is the same for the GMT-02,

The procedure is the same for the GMT-06, however, this tube has not been tested extensively enough.

**Once you have your Geiger Counter calibrated you may want to consider placing the circuit inside a case to protect yourself from the high voltage traces and pads on the PCB. , see figure 14.**



Figure 14

## Parts List

(1) PCB Printed Circuit Board	R12 (1) 100 ohm Resistor
C5 C6 C7 C8 (4) 0.01uF, 1KV Capacitors	R13 (1) 100K ohm Resistor
C1 (1) 0.1uF, 100V Capacitor	S1 (1) Toggle Switch (SW-07)
C2 (1) 330uF, 16V Capacitor	S2 (1) Slide Switch (SW-06)
C3 C4 (2) 10uF, 16V Capacitors	T1 (1) Mini Step up Transformer (HVT-06)
D1-D6 (6) 1N4007 Diodes, 1000V	U1 (1) 7805 Voltage Regulator
D7 (1) 5.1V Zener Diode (1N751)	U2 (1) LE33
D8 (1) 100V Zener Diode (1N5271B)	U3 (1) Bridge Rectifier (W01M)
D9 D10 (2) 200V Zener Diodes (1N5281B)	U4 (1) LM339N
D11 (1) Red Submin LED	(1) 14-pin IC Socket
P2 (1) 2.5mm Power Jack (PJ-102B)	SPK (1) Speaker (SPK-05)
Q1 (1) TIP 3055 Regulator (ALT. H1061)	J1(1) 2-pin Header
Q2 (1) 2N3094 Transistor	(1) Jumper
R2 (1) 33 ohm Resistor	(1) Battery Snap (BAT-01)
R3 R7 (2) 1 Mega ohm Resistors	OPTIONAL: GM TUBE
R4 (1) 470K ohm Resistor	
R5 (1) 10 Mega ohm Resistor	Additional parts included for alternate configurations.
ALT R5 (1) 3.3 Mega ohm Resistor	
R6 (1) 1 Mega ohm, Multi-turn Potentiometer	
R8 R9 R10 R11 R14 (5) 10K ohm Resistors	

### Components that are sold separately:

GMT-01	\$99.95
GMT-02	\$74.95
GMT-06	\$ 49.95
Mini Step-up transformer	\$ 12.00
Geiger Counter PCB	\$ 10.00

### Radioactive Sources:

Uranium Ore	\$39.95
CS-137 Source (5 uCi)	\$84.00 * Drop shipped from different location
CS-137 Source (10 uCi)	\$125.00* Drop shipped from different location



**Order from:**

Images Scientific Instruments, Inc.  
109 Woods of Arden Road  
Staten Island, NY 10312  
718-966-3694 Phone  
718-966-3695 Fax  
<http://www.imagesco.com>

**Helpful Links**

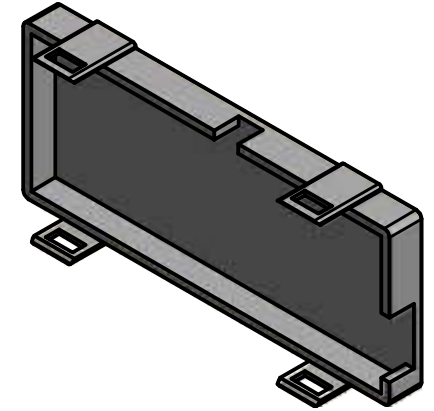
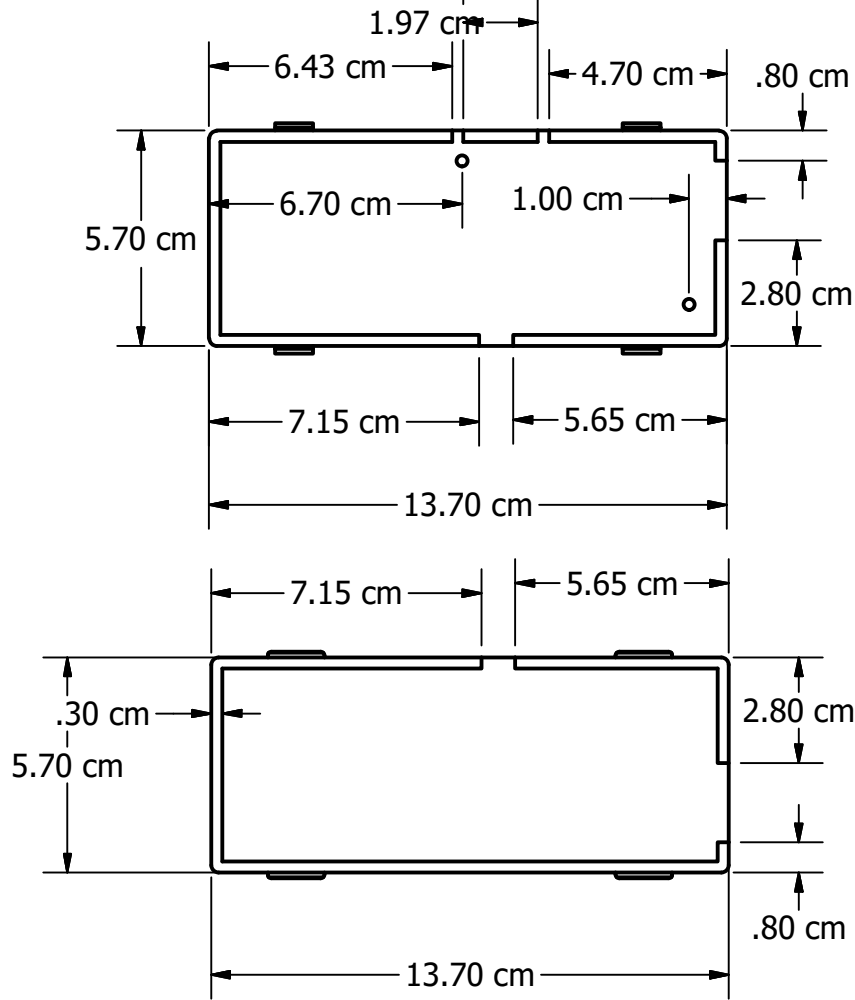
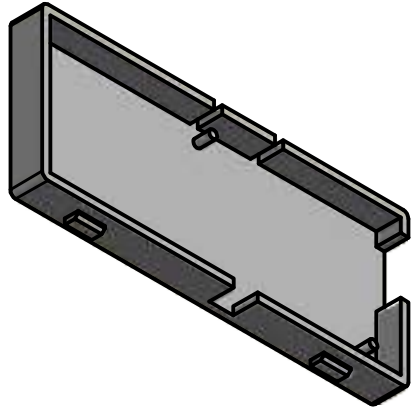
U.S. Nuclear Regulatory Commission  
<http://www.nrc.gov/>

CDC - Center for Disease Control maintains a radiation emergency web site:  
<http://www.bt.cdc.gov/radiation/index.asp#clinicians>

Health Physics Society  
<http://www.hps.org>

U.S. Environmental Protection Agency  
<http://www.epa.gov/radiation>

American Nuclear Society  
<http://www.ans.org/>



DRAWN cclea	2/6/2018	TITLE		
CHECKED				
QA				
MFG				
APPROVED		SIZE <b>A</b>	DWG NO	REV
		<b>1 / 2</b>	<b>GM Counter Box</b>	
		SCALE	SHEET 1 OF 1	

**REPREPER TECH CO., LIMITED**

Unit 04, 7/F, Bright Way Tower, No.33 Mong Kok Road,  
Kowloon, HK

**Phone:** (00852) 53372385

**Website:** [Http://www.reprap-walmart.com](http://www.reprap-walmart.com)

**Preparation date:** May 2012

## PLA Material Safety Data Sheet

### 1. IDENTIFICATION

**Chemical name:** polylactic acid.  
**Common names:** polylactic acid, PLA  
**Chemical formula:** (C<sub>6</sub>H<sub>8</sub>O<sub>5</sub>)<sub>n</sub>

### 2. Components

Chemical Name	Weight	OSHA Exposure Limits:	ACGIH Exposure Limits:
Poly lactide resin 9051-89-2	>90%	None	None
N,N Ethylene bistearamide	<5%	None	None
Typical Antioxidant	<5%	None	None
Typical Pigment	<5%	None	None

### 3. Physical Properties

Solubility in water: React moderate with water to become soluble. Will absorb water

Appearance: Solid filament

Density: 1.24g/cc

Melt temperature: 175~220°C

### 4. Hazardous Reactivity

Instability: None.

Incompatibility: Stable.

Decomposition: Slow reaction in the presence of water.

Polymerization: Will not occur, already a polymer.

Combustion: Carbon monoxide and / or carbon dioxide may form during the combustion of this product.

### 5. Explosion Hazard and Fire Data

Unusual Explosion Hazard and Fire : The material will burn if exposed to sufficient heat and an ignition source. Avoid dispersion of dust in the air to reduce dust explosion hazard potential.

Extinguished Media: Water, Carbon dioxide, Dry chemical powder, Foam.

Special Extinguishing Procedures: Firefighters must wear self-contained breathing apparatus and fully protective equipment.

### 6. Health Hazard Data

Health Hazards: May cause mild skin and eye irritation if reacted with water.

Medical Conditions Aggravated by exposure: None expected based on available information.

## 7. Precautions for Safe Handling and Use

Avoid contact with eyes, skin, and clothing. Avoid breathing dust. Wash thoroughly after handling. Hot and/or melted polymer can severely burn the skin. Handle with care.

## 8. Emergency and First Aid

Skin Contact: Solid or dust may cause irritation or corneal injury due to mechanical action

Eyes Contact: Essentially nonirritating to skin, Mechanical injury only

Inhalation: No harmful effects expected. Consult a physician.

Swallowing: No harmful effects expected. Consult a physician.

## 9. Special Protection Information

General Control Measures and procedures: None for normal use.

Personal Protective Equipment: Rubber gloves, safety glasses, Respirator.

## 10. Disposal Information

Spillage of Release : Collect for disposal. Use appropriate personal protective equipment during clean-up.

Waste disposal: Bury in a landfill in compliance with all federal, state and local regulations.

Material is non-hazardous and biodegradable.

## 11. Recommended Storage Conditions

Precautions should be taken in handling and storage: Avoid contacting with atmospheric moisture.

Store materials at <60 with a desiccant in original containers to maintain product quality. Keep the container closed until it is ready for use. Purge container with high-purity dry nitrogen after opening, before resealing or repackaging.

## 12. TRANSPORT INFORMATION

Shipping Containers: Samples bottles; Moisture proof laminated pouches.

Proper Shipping name: Not regulated as a hazardous by DOT OR IMO.

\*\*The Information Herein Is Given In Good Faith, But No Warranty, Express Or Implied, Is Made.

Consult the Company for Further Information.

**NOTICE REGARDING MEDICAL APPLICATION RESTRICTIONS:** The company does not recommend any of its products, including samples, for use: (A) in any application which is intended for any internal contact with human body fluids or body tissues (B) as a critical component in any medical device that supports or sustains human life; and (C) specifically pregnant women or in any applications designed specifically to promote or interfere with human reproduction.

## **2x4 Wood Block**

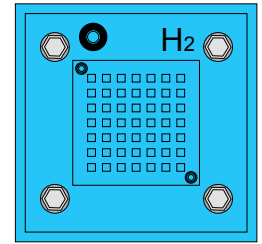
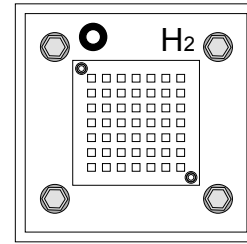
No manufacturer's specifications available.



**Product Ref No: 632000**

**Specifications:**

- High performance reversible PEM fuel cell
- Dimensions (w x h x d): 54mm x 54mm x 17mm
- Total Weight: 69.7grams
- Color: Blue or Transparent



**Electrolyzer function:**

When applying an electrical current (solar or D.C power), the reversible fuel cell acts as an electrolyzer that produces hydrogen and oxygen from water.

- Input Voltage: 1.8V ~ 3V (D.C.)
- Input Current: 0.7A
- Hydrogen production rate: 7ml per minute at 1A
- Oxygen production rate: 3.5ml per minute at 1A

**What is included:**

- PEM Reversible Fuel Cell
- Tubing
- Pins
- 2 x banana cables/ Connecting Leads
- Syringe

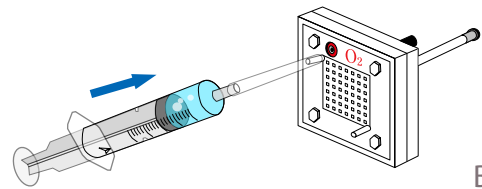
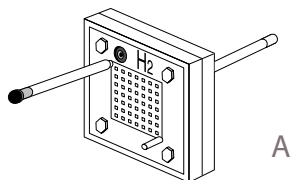
**What you need:**

- Battery pack or solar panel
- Distilled water
- Water/Gas Containers

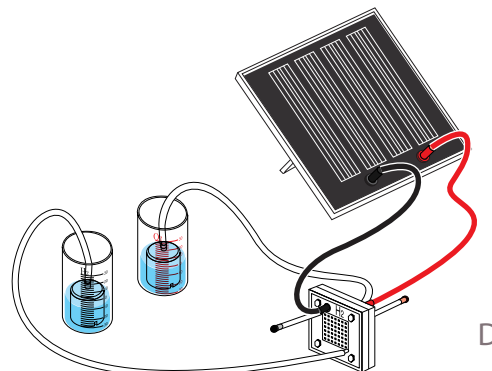
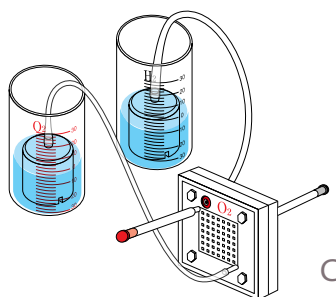
**PEM Reversible Fuel Cell- User Directions**

**Preparation of the Electrolyzer and Solar/Battery Powered Hydrogen Production**

1. Place the Electrolyzer onto a flat surface. Cut 2 x 4cm length pieces of rubber tube and insert a black pin into the end of one tube. Place the tube with the black pin into the top pin on the hydrogen side (with black terminal). Place the other tube firmly onto the top input nozzle on the oxygen side (see A).
2. Fill the syringe with DISTILLED water. On the red (oxygen) side of the electrolyzer, connect the syringe to the uncapped tube. Fill the electrolyzer until water begins to flow out of the tube. Place a red plug into the short tube located on the Oxygen side of electrolyzer. Let settle for 3 min (see B).



3. Place the outer water/gas containers onto a flat surface. Fill with distilled water up to the "0" line.
4. Place inner containers into outer cylinders minding that the gaps are not blocked by inner plastic rims. Make sure the water is still level to the "0" line. If not, remove some water with the syringe so that water level is at "0" line. Cut out two 20cm lengths of tubing.
5. Connect the tubes to the top nozzles on the inner containers. If the tubing is connected to the inner cylinders lastly there will be no air trapped inside the inner containers.
6. Connect the other end of one of the tubes to the bottom end of the black hydrogen side of the electrolyzer. Connect the end of the other tube to the bottom end of the red oxygen side of the electrolyzer (see C).
7. Connect the electrolyzer to the solar panel using the corresponding cables and expose to direct sunlight (see D). You can also use a Horizon battery pack and two AA batteries to connect to the electrolyzer as well. (Important: make sure connections are correct or permanent damage can occur.)



8. If the solar panel is placed in sufficiently strong sunlight, or battery pack is switched to the "On" position the system will now start to produce oxygen and hydrogen in the respective cylinders. When bubbles begin to surface in the hydrogen cylinder the cycle is complete. Disconnect the solar panel or battery pack from the electrolyzer.

Procedure for repeated gas production: Disconnect the small plugs from the tubes connected to the nozzles on the reversible fuel cell. This will allow water into the inner cylinders to replace the gasses and reset water levels to "0" line. Re-insert the plugs into the tubes and repeat electrolysis again.

\* The attached gold leads included with the PEM Electrolyzer and PEM fuel cells may be inserted into red/black terminals of the fuel cells if attaching other devices such as solar panels and small wind turbines using crocodile clip type leads/ cables. These may be also used to attach various loads to PEM fuel cells. We alternately provide 1 set of red/black 2mm banana plug leads/cables with each PEM electrolyzer and fuel cell that are designed to connect to Horizon solar panels and educational wind turbines.

#### Fuel Cell Function:

When applying a load, the reversible fuel cell is able to generate electricity from the hydrogen and oxygen gasses.

- Output Voltage (Parallel/Series): 0.6V(D.C)

- Output Current (Parallel/Series): 360mA

- Power: 210mW

Before applying a load you must perform electrolysis and capture sufficient hydrogen and oxygen gasses as in the previous steps.

**Note:** In order to obtain pure hydrogen in the containers, you should unplug the black pin on the hydrogen side of the fuel cell to release the hydrogen from the inner container of balloon/syringe. Re insert the black pin into the tube and repeat electrolysis process. This should be done the first time so as to purge impure gasses remaining in the containers that could negatively impact the performance of the fuel cell.

#### BUILDING AN APPLICATION FOR THE PEM FUEL CELL

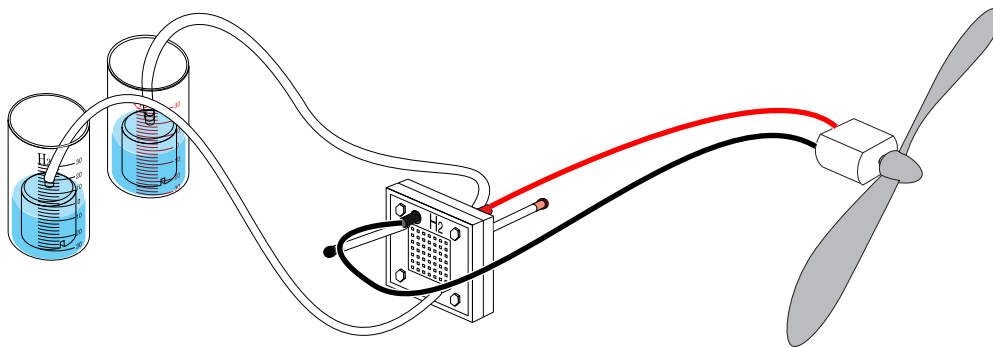
Several different types of devices can be commonly powered by the fuel cell such as small motors, LED lights, small water pumps, and other small electric devices requiring small amounts of power. Use your imagination in engineering new devices and applications using the fuel cell as its power system.

#### USING FUEL CELLS TO CONVERT HYDROGEN TO ELECTRICITY

Preparation of the Fuel Cell System

Using a PEM Reversible Fuel Cell to Power a Load

1. Place the reversible fuel cell in a secure position or onto a flat surface.
2. Connect the PEM reversible fuel cell to the motor or load you wish to power using the red and black connecting leads. Make sure to connect the black wire with the black terminals and red wire with the red terminals.
3. You should see the load begin to operate and use the electricity produced by the fuel cell. The load should begin to consume the hydrogen/oxygen fuels stored in the cylinders if there are sufficient levels of gasses available. If not, try gently squeezing the tubing to allow some of the gas to move into the fuel cell from the hydrogen storage container. As the load uses electricity the fuel cell will consume hydrogen from the cylinder and you will see the water level reflect the changes in amount of gases consumed.



#### Important:

- It is highly recommended to place the PEM Reversible Fuel Cell inside an air-tight plastic bag, such as a "Ziploc Bag." This will protect it when you are not using the kit.
- The positive and negative poles of the PEM Reversible Fuel Cell must be correctly connected to the power supply or damage may result.
- The membranes in the PEM Reversible Fuel Cell are to be used only when they are hydrated. Inject water only into the positive (oxygen) side of fuel cell and allow to soak for 3 minutes. The membranes will be damaged if connected to a solar panel or power supply when dry.
- It is highly recommended to use 3 W solar panel with 1A current or 2 new AA alkaline batteries with 1.5V as a power supply.

#### Note:

You can purchase the components used in the operation online from: [fuelcellstore.com](http://fuelcellstore.com)



[sales@fuelcellstore.com](mailto:sales@fuelcellstore.com)  
+1 (979) 703-1925

+1 (855) 251-0016 | sales@fuelcellstore.com

Currency My Account Login Create An Account



# FuelCellStore

Education, Research, and Fun since 1999

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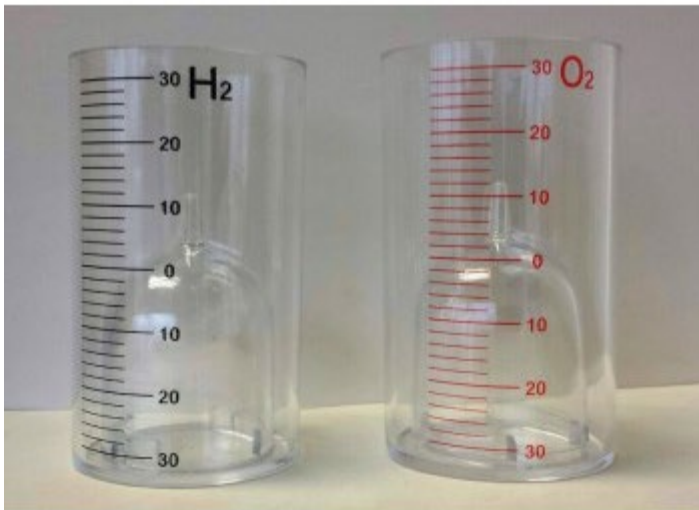
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0 item(s) - \$0.00

MENU ▾

Home » 30 mL Storage Cylinders (2)



 Zoom





# 30 mL Storage Cylinders (2)

**Brand:** Horizon Fuel Cell Technologies

**Product Code:** 7110307

**Price:**  \$17.00

Qty:

[Add to Cart](#)

- OR -

[Add to Wish List](#)

[Add to Compare](#)

## RECOMMENDED ACCESSORIES:



Horizon Silicon Tubing - 5 Feet

\$10.00

Qty:

[Add to Cart](#)

★★★★★ 1 reviews | [Write a review](#)

### Description

### Spare Parts

### Reviews (1)

These two storage cylinders, one for hydrogen and one for oxygen, can be used to store 30 milliliters (mL) of hydrogen and oxygen to be used to power a Proton Exchange Membrane Fuel Cell (PEMFC) or any other application requiring gasses.

#### Contents Include:

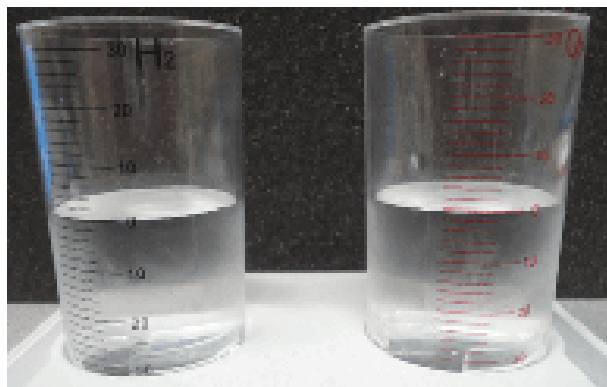
2 x Cylindrical Beakers

2 x Inner Containers

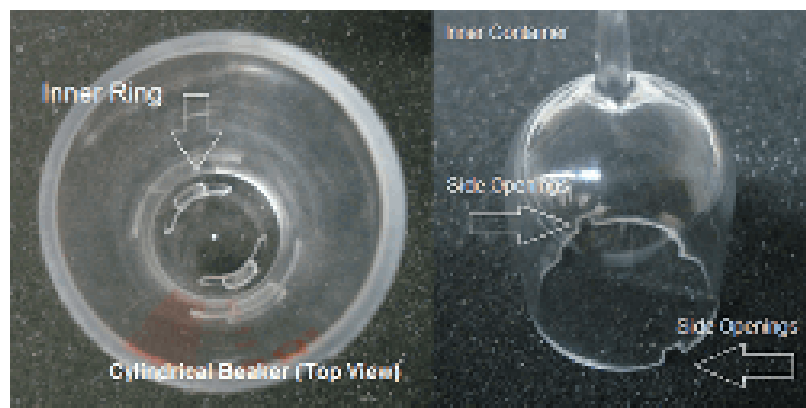
**Need Extra Tubing?** - [Horizon's 2mm Inner Diameter Silicon Tubing](#) is a perfect fit for the 30mL Storage Cylinders.

#### How Do They Work?

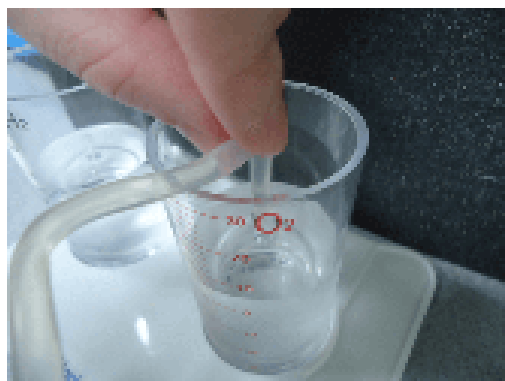
**Step 1)** Fill the two cylindrical beakers with distilled water until the water level reaches zero.



**Step 2)** Place the two inner containers into the cylindrical beakers (make sure the side openings on the inner container is not blocked by the inner ring on the beakers), the distilled water from the beaker will fill out the inner container at this point.



**Step 3)** Connect two long tubes to the inner container on each of the beakers corresponding to oxygen and hydrogen on the fuel cell. (Make sure there is no air in the inner containers)



## RELATED PRODUCTS (13)



Horizon Silicon Tubing - 5 Feet

\$10.00



Add to Cart



RFC H2/O2/Air

Request a Quote



Mini Water Pump

\$8.95

Add to Cart



Horizon Mini PEM Electrolyzer

\$55.50



Add to Cart



MINI PEM Fuel Cell - Green

\$52.00

Add to Cart



Horizon Mini PEM Fuel Cell

\$52.00



Add to Cart



Electrolyzer Cell 10

\$200.00

Add to Cart



Storage 80

Request a Quote



Solar Hydrogen Education Kit

\$90.29



Add to Cart



Electrolyzer Cell 5

\$139.00

Add to Cart



Intelligent Fuel Cell Car Lab

\$88.19



Add to Cart



Storage 30

Request a Quote



Horizon Mini PEM  
Reversible Fuel Cell

\$63.00







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### Information

### Customer Service

### Extras

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 College Station, Texas, USA     1 (855) 251-0016     sales@fuelcellstore.com  
 +1 (979) 703-1925



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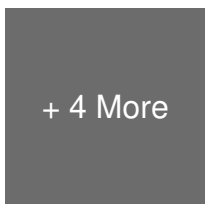
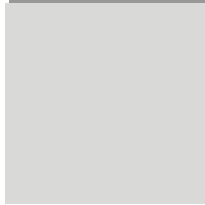
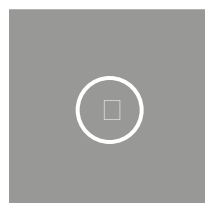
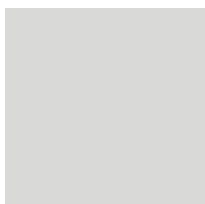
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PRODUCTS

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# BLACK GORILLA TAPE

Gorilla Tape is 3X stronger\* for a hold that lasts. Made with double-thick adhesive, strong reinforced backing, and a tough all-weather shell, this duct tape is great for projects and repairs both indoors and out. Gorilla tape sticks to smooth, rough and uneven surfaces, including wood, stone, stucco, brick, metal and vinyl. Gorilla Tape, for the Toughest Jobs on Planet Earth®.

\*compared to a leading value brand duct tape based on 2017 IRI data

## Sizes

1" Gorilla Tape To-Go



[View product details](#)



## PRODUCT FEATURES

**DOUBLE THICK ADHESIVE:** Grips smooth, rough and uneven surfaces

**TOUGH, REINFORCED BACKING:** The tight weave contributes to the heft, but Gorilla Tape can still be torn by hand.

**RUGGED, WEATHER-RESISTANT SHELL:** Withstands moisture, UV rays and temperature changes.



## DIRECTIONS

Use like any other tape. Tear Gorilla Tape by hand or cut to size with a knife or scissors. Apply the tape carefully, smoothing out any pockets or rolls. That's it. Enjoy the strength and durability of Gorilla Tape!

For First Aid and SDS information, [click here](#).

## TECHNICAL SPECS



**APPLICATION TEMPERATURE** – 40° to 120° F, best at room temperature

**SERVICE TEMPERATURE** – continuous-up to 150° F intermittent- up to 200° F

**OUTDOOR** – Yes

**MOISTURE RESISTANT** – Yes

**STORAGE TIPS** – Store in a cool, dry location. Keep out of direct sunlight

## FAQS



### **Can Gorilla Tape be used instead of electrical tape?**

Gorilla Tape should NOT be used as an electrical tape.

### **Will Gorilla Tape work on plastic/vinyl/rubber?**

Gorilla Tape contains a highly concentrated rubber based adhesive and sticks to most plastics, including polyethylene (PE) and polypropylene (PP). Gorilla Tape does not work on materials with high oil or plasticizer content, such as EPDM rubber or PVC. An acrylic tape, such as Crystal Clear Gorilla Tape, may be better suited for these materials.

### **Is Gorilla Tape food safe?**

Gorilla Tape is not recommended for direct or indirect food contact and should not be considered food safe.

### **What if my pet has Gorilla Tape on their skin/fur?**

Do not remove. For more direction call 1-800-420-7186 anytime to reach a member of our product safety team. Additional product safety and first aid information can be found [here](#).

## RECOMMENDED PRODUCTS



SILVER GORILLA TAPE



WHITE GORILLA TAPE



GORILLA TOUGH & CLEAR MOUNTING TAPE

**For the Toughest Jobs on Planet Earth™**



[Product Guide](#) [First Aid / SDS](#) [International Distributors](#) [Careers](#) [Contact](#) [Privacy](#)

[Sitemap](#)

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# Safety Data Sheet - Gorilla Tape (Black, Silver, White, Camo, & High Visibility)

Date Revised: 12/6/2016

Date Issued: 12/6/2016

Version: 1.1

## FOR CHEMICAL EMERGENCY:

During Business Hours: (800) 966-3458 | Outside Business Hours: (800) 420-7186

According to Federal Register/Vol. 77, No. 58/Monday, March 26, 2012/Rules and Regulations

## SECTION 1: IDENTIFICATION

### Product Identifier

**Product Name:** Gorilla Tape (Black, Silver, White, Camo, High Visibility)

**Synonyms:** Polymer based pressure sensitive adhesive

**Article Exemption:** Within the meaning of the OSHA Hazard Communication Standard [29 CFR 1910.1200]: this mixture is not considered a hazard when used in a manner which is consistent with the labeled directions. This mixture is considered an article in its final form.

### Intended Use of the Product

Tape

### Name, Address, and Telephone of the Responsible Party

#### **Company**

The Gorilla Glue Company

2101 E. Kemper Road

Cincinnati, Ohio 45241

513-271-3300

[www.gorillatough.com](http://www.gorillatough.com)

### Emergency Telephone Number

**Emergency number** : 1-800-420-7186 (Prosar)

## SECTION 2: HAZARDS IDENTIFICATION

### Classification of the Substance or Mixture

#### **Classification (GHS-US)**

Not classified

### Label Elements

**GHS-US Labeling** No labeling applicable

### Other Hazards

**Other Hazards Not Contributing to the Classification:** No additional information available

**Unknown Acute Toxicity (GHS-US)** Not available

## SECTION 3: COMPOSITION/INFORMATION ON INGREDIENTS

Quantities of compounds contained in this product are not reportable under the article exemption since they do not release or otherwise result in exposure of a hazardous chemical under normal conditions of use.

## SECTION 4: FIRST AID MEASURES

### Description of First Aid Measures

**General:** Never give anything by mouth to an unconscious person. If you feel unwell, seek medical advice (show the label if possible).

**Inhalation:** If inhaled, remove to fresh air and keep at rest in a position comfortable for breathing. If you feel unwell, seek medical advice.

**Skin Contact:** Remove contaminated clothing. Gently wash with plenty of soap and water followed by rinsing with water for at least 15 minutes. Call a POISON CENTER or doctor/physician if you feel unwell. Wash contaminated clothing before reuse.

**Eye Contact:** Rinse cautiously with water for at least 15 minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Obtain medical attention.

**Ingestion:** Rinse mouth. Do not induce vomiting. Immediately call a POISON CENTER or doctor/physician.

### Most Important Symptoms and Effects Both Acute and Delayed

**General:** Prolonged contact may cause irritation. Vapors may cause drowsiness and dizziness.

**Inhalation:** Prolonged, repeated inhalation of adhesive may cause dizziness and drowsiness.

**Skin Contact:** Repeated or prolonged skin contact may cause irritation.

**Eye Contact:** Contact may cause irritation due to mechanical abrasion.



# Safety Data Sheet - Gorilla Tape (Black, Silver, White, Camo, & High Visibility)

Date Revised: 12/6/2016

Date Issued: 12/6/2016

Version: 1.1

## FOR CHEMICAL EMERGENCY:

During Business Hours: (800) 966-3458 | Outside Business Hours: (800) 420-7186

According to Federal Register/Vol. 77, No. 58/Monday, March 26, 2012/Rules and Regulations

**Ingestion:** Ingestion is likely to be harmful or have adverse effects.

**Chronic Symptoms:** Repeated or prolonged skin contact may cause irritation.

### **Indication of Any Immediate Medical Attention and Special Treatment Needed**

If medical advice is needed, have product container or label at hand.

## **SECTION 5: FIRE-FIGHTING MEASURES**

### **Extinguishing Media**

**Suitable Extinguishing Media:** Use extinguishing media appropriate for surrounding fire.

**Unsuitable Extinguishing Media:** Do not use a heavy water stream. Use of heavy stream of water may spread fire.

### **Special Hazards Arising From the Substance or Mixture**

**Fire Hazard:** Not flammable.

**Explosion Hazard:** Product is not explosive.

**Reactivity:** None known.

### **Advice for Firefighters**

**Precautionary Measures Fire:** Exercise caution when fighting any chemical fire.

**Firefighting Instructions:** Do not allow run-off from fire fighting to enter drains or water courses.

**Protection During Firefighting:** Do not enter fire area without proper protective equipment, including respiratory protection.

**Hazardous Combustion Products:** None known.

### **Reference to Other Sections**

Refer to section 9 for flammability properties.

## **SECTION 6: ACCIDENTAL RELEASE MEASURES**

### **Personal Precautions, Protective Equipment and Emergency Procedures**

**General Measures:** Do not get in eyes, on skin, or on clothing.

#### **For Non-Emergency Personnel**

**Protective Equipment:** Use appropriate personal protection equipment (PPE).

**Emergency Procedures:** Evacuate unnecessary personnel.

#### **For Emergency Personnel**

**Protective Equipment:** Equip cleanup crew with proper protection.

**Emergency Procedures:** Keep area ventilated.

### **Environmental Precautions**

Prevent entry to sewers and public waters.

### **Methods and Material for Containment and Cleaning Up**

**For Containment:** Absorb and/or contain spill with inert material, then place in suitable container.

**Methods for Cleaning Up:** Dispose of waste safely and in accordance with local, state, and federal regulations.

### **Reference to Other Sections**

See heading 8, Exposure Controls and Personal Protection. Concerning disposal elimination after cleaning, see item 13.

## **SECTION 7: HANDLING AND STORAGE**

### **Precautions for Safe Handling**

**Hygiene Measures:** Handle in accordance with good industrial hygiene and safety procedures. Wash hands and other exposed areas with mild soap and water before eating, drinking, or smoking and again when leaving work.

### **Conditions for Safe Storage, Including Any Incompatibilities**

**Storage Conditions:** Store in a dry, cool and well-ventilated place. Store away from heat.

**Incompatible Materials:** None known.

**Specific End Use(s)** Tape



# Safety Data Sheet - Gorilla Tape (Black, Silver, White, Camo, & High Visibility)

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## SECTION 8: EXPOSURE CONTROLS/PERSONAL PROTECTION

### Control Parameters

Not applicable

### Exposure Controls

**Appropriate Engineering Controls:** Emergency eye wash fountains and safety showers should be available in the immediate vicinity of any potential exposure. Provide sufficient ventilation to keep vapors below permissible exposure limit. Ensure all national/local regulations are observed.

**Personal Protective Equipment:** Gloves. Safety glasses.



**Materials for Protective Clothing:** Not available

**Hand Protection:** Chemically resistant gloves are recommended, but not required.

**Eye Protection:** Chemical goggles or safety glasses.

**Skin and Body Protection:** Wear suitable working clothes.

**Respiratory Protection:** Not required for normal conditions of use. Use a NIOSH-approved respirator or self-contained breathing apparatus whenever exposure may exceed established Occupational Exposure Limits.

**Other Information:** When using, do not eat, drink or smoke.

## SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

### Information on Basic Physical and Chemical Properties

Physical State	:	Solid
Appearance	:	Black, Silver, White, Camo, Orange
Odor	:	Slight
Odor Threshold	:	Not available
pH	:	Not applicable
Evaporation Rate	:	Not available
Melting Point	:	Not available
Freezing Point	:	Not available
Boiling Point	:	Not available
Flash Point	:	Not available
Auto-ignition Temperature	:	Not available
Decomposition Temperature	:	Not available
Flammability (solid, gas)	:	Not available
Lower Flammable Limit	:	Not available
Upper Flammable Limit	:	Not available
Vapor Pressure	:	Not available
Relative Vapor Density at 20 °C	:	Not available
Relative Density	:	Not available
Specific Gravity	:	Not available
Solubility	:	Non-soluble
Partition Coefficient: N-Octanol/Water	:	Not available
Viscosity	:	Not available
Explosion Data – Sensitivity to Mechanical Impact	:	Not expected to present an explosion hazard due to mechanical impact.



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**Explosion Data – Sensitivity to Static Discharge** : Not expected to present an explosion hazard due to static discharge.

## SECTION 10: STABILITY AND REACTIVITY

**Reactivity:** None known.

**Chemical Stability:** Stable under recommended handling and storage conditions (see section 7).

**Possibility of Hazardous Reactions:** Hazardous polymerization will not occur.

**Conditions to Avoid:** Direct sunlight. Extremely high or low temperatures.

**Incompatible Materials:** Strong acids, strong bases, strong oxidizers.

**Hazardous Decomposition Products:** Carbon oxides (CO, CO<sub>2</sub>). Nitrogen compounds. Acrolein. Aldehydes.

## SECTION 11: TOXICOLOGICAL INFORMATION

### Information on Toxicological Effects - Product

**Acute Toxicity:** Not classified

**LD50 and LC50 Data:** Not available

**Skin Corrosion/Irritation:** Not classified

**pH:** Not applicable

**Serious Eye Damage/Irritation:** Not classified

**pH:** Not applicable

**Respiratory or Skin Sensitization:** Not classified

**Germ Cell Mutagenicity:** Not classified

**Teratogenicity:** Not available

**Carcinogenicity:** Not classified.

**Specific Target Organ Toxicity (Repeated Exposure):** Not classified

**Reproductive Toxicity:** Not classified

**Specific Target Organ Toxicity (Single Exposure):** Not classified

**Aspiration Hazard:** Not classified

**Symptoms/Injuries After Inhalation:** Prolonged, repeated inhalation of adhesive may cause dizziness and drowsiness.

**Symptoms/Injuries After Skin Contact:** Repeated or prolonged skin contact may cause irritation.

**Symptoms/Injuries After Eye Contact:** Contact may cause irritation due to mechanical abrasion.

**Symptoms/Injuries After Ingestion:** Ingestion is likely to be harmful or have adverse effects.

**Chronic Symptoms:** Repeated or prolonged skin contact may cause irritation.

### Information on Toxicological Effects - Ingredient(s)

**LD50 and LC50 Data:** Not applicable

## SECTION 12: ECOLOGICAL INFORMATION

**Toxicity** Not classified

**Persistence and Degradability** Not available

**Bioaccumulative Potential** Not available

**Mobility in Soil** Not available

### Other Adverse Effects

**Other Information:** Avoid release to the environment.

## SECTION 13: DISPOSAL CONSIDERATIONS

**Sewage Disposal Recommendations:** Do not dispose of waste into sewer.

**Waste Disposal Recommendations:** Dispose of waste material in accordance with all local, regional, national, provincial, territorial and international regulations.



# Safety Data Sheet - Gorilla Tape (Black, Silver, White, Camo, & High Visibility)

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## SECTION 14: TRANSPORT INFORMATION

**In Accordance with DOT** Not regulated for transport

**In Accordance with IMDG** Not regulated for transport

**In Accordance with IATA** Not regulated for transport

**In Accordance with TDG** Not regulated for transport

## SECTION 15: REGULATORY INFORMATION

**US Federal Regulations** Not applicable

**US State Regulations** Not applicable

**Canadian Regulations**

### Gorilla Tape (Black, Silver, White, Camo, High Visibility)

WHMIS Classification	This is not a controlled product under WHMIS. This product meets the definition of a "manufactured article" and is not subject to the regulations of the Hazardous Products Act.
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This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations (CPR) and the SDS contains all of the information required by CPR.

## SECTION 16: OTHER INFORMATION, INCLUDING DATE OF PREPARATION OR LAST REVISION

**Revision Date** : 12/6/2016

**Other Information** : This document has been prepared in accordance with the SDS requirements of the OSHA Hazard Communication Standard 29 CFR 1910.1200.

### Party Responsible for the Preparation of This Document

The Gorilla Glue Company

+1 513-271-3300

*The information presented in this Safety Data Sheet was prepared by qualified personnel and to the best of our knowledge is true and accurate. The information and recommendations are furnished for this product with the understanding that the purchaser will independently determine the suitability of the product for this purpose. This data does not constitute a warranty, expressed or implied, statutory or otherwise, nor is it representation for which The Gorilla Glue Company assumes legal responsibility. The data is submitted for the user's information and consideration only. Any use of this product must be determined by the user to be in accordance with applicable federal, state, provincial and local laws and regulations.*

North America GHS US 2012 & WHMIS 2 GG

**PVC 3/8" x Tubing**

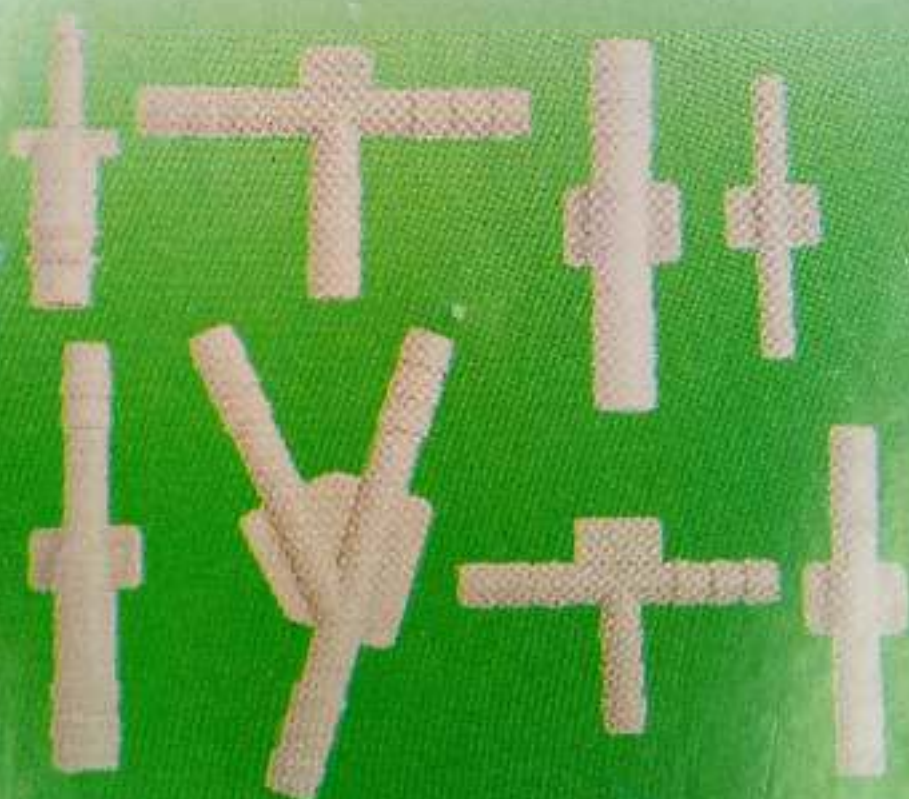
No manufacturer's specifications available.



47380

**DORMAN**<sup>®</sup>  
**HELP!**<sup>®</sup>

**VACUUM CONNECTOR ASSORTMENT**  
**SURTIDO DE CONECTORES DE VACÍO**  
**ASSORTIMENT DE CONNEXEURS DE VACUUM**



QTY: 65

CONT: 65 PIEZAS

QTÉ : 65

**UNDERHOOD • BAJO EL COFRE • SOUS LE CAPOT**

**CONNECTORS**

$1/8" \times 1/8"$

**CONECTORES**

3,17 mm x 3,17 mm

**CONNECTEURS**

1/8 po x 1/8 po

**CONNECTORS**

$3/16" \times 3/16"$

**CONECTORES**

4,76 mm x 4,76 mm

**CONNECTEURS**

3/16 po x 3/16 po

**CONNECTORS**

$1/4" \times 1/4"$

**CONECTORES**

6,35 mm x 6,35 mm

**CONNECTEURS**

1/4 po x 1/4 po

**TEES**

$5/32" \times 5/32" \times 5/32"$

**TES**

3,96 mm x 3,96 mm x 3,96 mm

**PIÈCES EN "T"**

5/32 po x 5/32 po x 5/32 po

**TEES**

$3/16" \times 3/16" \times 3/16"$

**TES**

4,76 mm x 4,76 mm x 4,76 mm

**PIÈCES EN "T"**

3/16 po x 3/16 po x 3/16 po

**"Y" TEES**

$3/16" \times 3/16" \times 3/16"$

**TES DE "Y"**

4,76 mm x 4,76 mm x 4,76 mm

**PIÈCES EN "Y"**

3/16 po x 3/16 po x 3/16 po

**CONNECTORS**

$1/4" \times 1/8"$

**CONECTORES**

6,35 mm x 3,17 mm

**CONNECTEURS**

1/4 po x 1/8 po

**CONNECTORS**

$1/4" \times 3/16"$

**CONECTORES**

6,35 mm x 4,76 mm

**CONNECTEURS**

1/4 po x 3/16 po



47380

12300

### CONTENTS

**Tees - 5 each of the following:**

5/32" x 5/32" x 5/32", 3/16" x 3/16" x 3/16"

"Y" Tee - 5: 3/16" x 3/16" x 3/16"

**Connectors - 10 each of the following:**

1/8" x 1/8", 3/16" x 3/16", 1/4" x 1/4",

1/4" x 1/8", 1/4" x 3/16"

---

### INCLUYE

**Tes - 5 por cada uno del siguiente:**

3,96 mm x 3,96 mm x 3,96 mm,

4,76 mm x 4,76 mm x 4,76 mm

**Tes de "Y" - 5: 4,76 mm x 4,76 mm x 4,76 mm**

**Conectores - 10 por cada uno del siguiente:**

3,17 mm x 3,17 mm, 4,76 mm x 4,76 mm,

6,35 mm x 6,35 mm, 6,35 mm x 3,17 mm,

6,35 mm x 4,76 mm

---

### CONTENU

**Pièces en "T" - 5 de chacun de ce qui suit :**

5/32 po x 5/32 po x 5/32 po, 3/16 po x 3/16 po x 3/16 po

**Pièces en "Y" - 5: 3/16 po x 3/16 po x 3/16 po**

**Connecteurs - 10 de chacun de ce qui suit :**

1/8 po x 1/8 po, 3/16 po x 3/16 po, 1/4 po x 1/4 po,

1/4 po x 1/8 po, 1/4 po x 3/16 po



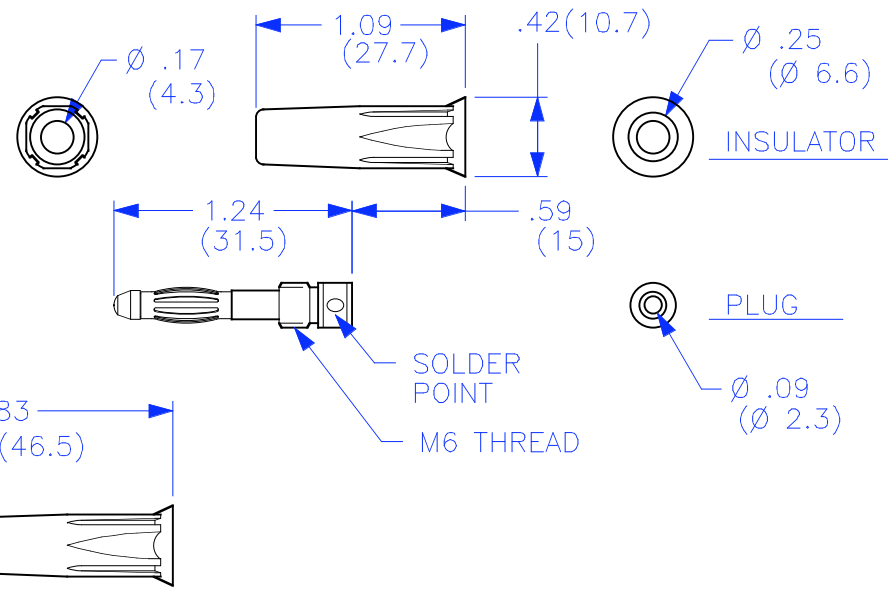
**MADE IN CHINA.  
HECHO EN CHINA.  
FABRIQUÉ EN CHINE.**

HELP!<sup>®</sup>, Product Line of Dorman<sup>®</sup> AutoGrade<sup>™</sup>  
3400 E Walnut St., Colmar, PA 18915-9768 U.S.A.  
© 2012 and prior Dorman Products, Inc.

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REVISIONS			
REV.	DESCRIPTIONS	DATE	APPROVED
—	CLASS A RELEASED	7/11/99	

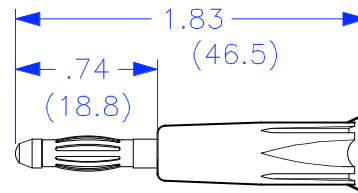
- DO-IT-YOURSELF (DIY) 4mm IN-LINE PLUG, SOLDER ATTACHMENT.
- SPECIFICATIONS:  
 INSULATOR BODY: POLYAMIDE (NYLON)  
 PLUG BODY: BRASS, NICKEL PLATED  
 SPRING CONTACT: BRONZE-BERYLLIUM, NICKEL PLATED
- RATING:  
 VOLTAGE: 1,200V AC/DC  
 CURRENT: 36A MAX.  
 TEMPERATURE: -20° C TO +80° C.
- MAXIMUM WIRE SIZES:  
 CONDUCTOR:  $\varnothing$ .090 (12AWG)  
 STRIP LENGTH: .25 (6.4)



**PART NUMBER**

**CT2002-#**

- COLOR:
- 0 — BLACK
  - 2 — RED
  - 4 — YELLOW
  - 5 — GREEN
  - 6 — BLUE
  - 9 — WHITE



ASSEMBLED

THIRD ANGLE PROJECTION		UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS DECIMALS $\pm 1/32$ .XX $\pm .02$ .XXX $\pm .005$ DO NOT SCALE DRAWING	CONTRACT NO.		<b>Cal Test Electronics</b> 22820 Savi Ranch Parkway Yorba Linda, CA 92887-4610			
			APPROVALS	DATE	TITLE			
NEXT ASSY		MATERIAL	DRAWN	7/11/99	<b>DIY 4mm PLUG, SOLDER</b>			
USED ON		FINISH	CHECKED	ENGR.	SIZE	CAGE CODE	DWG. NO.	REV.
APPLICATION			DESIGN ACTIVITY		A	43F45	P200200	—
					SCALE	1:1		SHEET 1 OF 1

**The Tough Elastic Sealant for Every Job**

# LEXEL®

**Sticks to Almost Anything\***



**DESCRIPTION:**

Super-elastic. Superior adhesion. Paintable. It seals around anything: tubs and shower stalls, sinks and counter tops, window frames and door frames, PVC and metal pipes. Apply to wet or dry surfaces, indoors and outdoors. It's tough and can handle up to 800% joint movement. It's scrubbable. It sticks to just about anything. Lexel clear sealant is 19 times clearer than silicone and won't yellow or cloud up over time. Lexel won't let you down.

**WHERE TO USE:**

- In most any place you'd use silicone, including:
- Kitchens and bathrooms, including fixtures, countertops and backsplashes
  - On wallpaper edges to prevent curling
  - Around trim, windows, doors, thresholds, sills, siding, vents, pipes and air conditioners
  - Around leaky duct work

**\*ADHERES TO:** (all conform to ASTM C794)

Most building materials including:

**Metals**

- Aluminum
- Brass
- Steel
- Copper
- Silver

**Plastics**

- ABS
- Vinyl
- Nylon
- PVC
- Fiberglass
- Acrylic Sheet
- Plexiglass
- Lexan®\*\*
- Nylon
- Polycarbonate

**OTHER SURFACES:**

- Asphalt
- Concrete
- Glass
- Wood
- Corian®\*\*
- Cement
- Thinset
- Stone
- Drywall
- Stucco
- EIFS
- Brick
- Mortar
- Ceramic Tile
- Formica®\*\*
- Fiber Cement
- Alkyd Stain
- Cloth/Canvas
- Porcelain

**COLORS:**

- Clear
- White

**PACKAGING:**

- 10.5 oz. plastic cartridges
- 5 oz. squeeze tubes

**COVERAGE:**

A 10.5 oz. cartridge will yield approx. 26 lineal feet with a ¼" (6 mm) bead.

**PAINTABILITY:**

With latex paint/stain after 24-48 hours or oil-based paint/stain after 3-4 weeks

\*\* Corian®, Lexan® and Formica® are registered trademarks of their respective owners.

**FEATURES**

- 19 times clearer than silicone
- Super elastic with strong adhesion, won't tear, crack or pull away
- Paintable
- Water & mildew-resistant
- Won't freeze
- Use on wet or dry surfaces
- Tough & easily cleaned
- Limited Lifetime Warranty
- Exclusive stop flow plunger
- High durability
- Full 10.5 oz. in every cartridge

**BENEFITS**

- No cloudiness or ugly caulk lines
- Eliminates costly call backs
- Unlike silicone, paint sticks with no separation
- Use indoors or outdoors
- No wasted caulk in cold weather
- Apply in most any weather
- Clean with abrasive cleaners with no damage
- Have confidence that you're using the right product
- Less waste, less mess
- Performs well in most any type of climate
- More for your money

#### WHERE NOT TO USE:

- Areas of submersion where there is animal life (i.e. aquariums)
- With polystyrene insulation
- Containment applications
- Plastics not listed should be tested for compatibility before use
- Will not adhere to or is incompatible with Aquaseal<sup>®</sup>, cultured marble, Kynar<sup>®</sup>, polypropylene, polystyrene foam insulation, polyethylene, rubber, silicone, styrofoam (it dissolves it), vulcanized rubber, waxes

#### APPLICATION:

- Large beads applied in hot weather (above 95°F) may exhibit slight bubbling. For best results, apply out of direct sunlight.
- Prepare frosty or icy surfaces by cleaning with alcohol.
- If using indoors, make sure the room is well-ventilated.
- Natural shrinkage may give some joints a concave appearance. Multiple applications may be needed to fill the joint flat.
- If dirt or oils are present on the substrate, wash with any household cleaner, rinse to remove and allow to thoroughly dry.
- Remove any old caulk, especially silicone or silicone residue. Use a silicone remover.
- Insert backer rod into joints deeper than 1/2" to provide for proper sealant depth and a stronger, longer lasting seal.

#### Cartridge:

- Gun Lexel into the joint with a caulk gun.

#### Squeeze Tube:

- Squeeze Lexel into the joint.
- Tool for a smoother bead using a caulking tool or a soapy finger and a light, skimming touch.

#### STORAGE AND CLEAN-UP:

- Clean tools with mineral spirits, paint thinner or citrus-based cleaners.
- Clean hands with citrus-based cleaners.
- Lexel cartridges can be stored if sealed tightly. Wrap cartridge nozzles tightly with plastic wrap and a rubber band.
- Lexel squeeze tubes can be stored by tightly replacing the cap.

#### TYPICAL PROPERTIES:

Property	Value
Joint Size	Maximum 2"
Clarity (NTU):	< 13
Radon Barrier:	Stops 94%
Application Range	0°F to 120°F (-18°C to 49°C) surface temperature
Service Range	-30°F to 200°F (-34°C to 93°C)
Freeze-Thaw Stability	Won't freeze
Tensile Properties	Recovery at 50% stretch: 96% in 1 min Recovery at 100% stretch: 96% in 1 min
VOC	Clear <sup>1</sup> & White <sup>3,4</sup> Cartridge: ≤380 g/L, <43 wt% Clear <sup>2</sup> & White <sup>3,4</sup> Squeeze Tube: ≤410 g/L, <47 wt% White Lower VOC Cartridge <sup>3</sup> & Squeeze Tube <sup>3</sup> : ≤40 g/L, <4 wt% Clear Lower VOC Squeeze Tube: ≤380 g/L, <43 wt%

#### TEST DATA:

Property	Results	Test Method
Durability	25% total joint movement (10 cycles @ -15°F (-26°C))	ASTM C719
Hardness, Shore A	25 (21-day cure)	ASTM C661
Slump	< 1/8"	ASTM D2202
Solids	46-59% by weight depending on product	ASTM C1250
Extrusion Rate	80 g/min (1/8" orifice at 40 psi)	ASTM C603
Cured	1 week (dependent on temperature, humidity and bead size/thickness)	ASTM C679
Tack-free	Less than 30 minutes	ASTM C679
Low Temp. Flexibility	Pass (not artificially weathered)	ASTM C734
Adhesion-in-peel Passing Substrates	See "ADHERES TO" section on front page	ASTM C794

#### SPECIFICATIONS:

- Meets FHA requirements.

The data reported here are believed to be reliable. No warranty is made concerning the accuracy of or the results obtained from their use.

\* Aquaseal<sup>®</sup> and Kynar<sup>®</sup> are registered trademarks of their respective owners.

<sup>1</sup> Clear Cartridge sold in all 50 US states and Canada.

<sup>2</sup> Clear Squeeze Tube not for sale in California. Clear Squeeze Tube Lower VOC required in California.

<sup>3</sup> All White products not for sale in California.

<sup>4</sup> White Cartridge and White Squeeze Tube not for sale in CT, DC, DE, IL, IN, MA, MD, ME, MI, NH, NJ, NY, OH, PA, RI, UT (select counties), VA (select counties), VT, and Canada. White Cartridge Lower VOC and White Squeeze Tube Lower VOC required in these areas.

**DANGER:** VAPOR HARMFUL. FLAMMABLE. EYE & SKIN IRRITANT. Do not swallow. Do not breathe fumes. Do not use near heat, sparks or flames. Do not smoke. Do not get in eyes. Do not get on skin or clothing. KEEP OUT OF REACH OF CHILDREN. Wear safety glasses and chemical resistant gloves. Use only in a well-ventilated area.

Contains toluene.

**FIRST AID:** If swallowed, call a Poison Control Center or doctor immediately. Do not induce vomiting. If in eyes, rinse with water for 15 minutes. If on skin, rinse well with water. If breathed in, move person into fresh air.

**LIMITED LIFETIME WARRANTY:** Sashco warrants this product will substantially meet published specifications on the date of sale. If it fails to do so, return unused portion with original sales receipt for replacement or refund, at Sashco's sole option. These are purchaser's sole and exclusive remedies for any breach of warranty. Purchaser must determine suitability of product for purchaser's specific needs and assumes all risk associated with its use. Sashco will not be liable for direct or indirect damages.

For a detailed description of the warranty & exclusions, visit [www.sashco.com](http://www.sashco.com).



10300 E. 107th Pl., Brighton, CO 80601  
800-767-5656 • [www.sashco.com](http://www.sashco.com)

Made in the USA

Follow Sashcoinc on:





### SECTION 1: Identification

#### 1.1. Identification

Product form : Mixture  
 Product name : Lexel White  
 Other means of identification : Lexel White Cartridge Grade & Lexel White Squeeze Tube Grade

#### 1.2. Recommended use and restrictions on use

Use of the substance/mixture : Caulking

This SDS is designed for workplace employees, emergency personnel and for other situations where there is potential for large-scale or prolonged exposure, in accordance with the OSHA requirements.

This SDS is not applicable for consumer use of our products. For consumer use, all precautionary and first aid language is provided on the product label, MSDS or both in accordance with applicable government regulations

#### 1.3. Supplier

##### Supplier

Sashco Inc  
 10300 E. 107th Place  
 Brighton, CO 80601 - USA  
 T 800 767 5656  
[info@sashco.com](mailto:info@sashco.com)

#### 1.4. Emergency telephone number

Emergency number : 800 535 5053

### SECTION 2: Hazard(s) identification

#### 2.1. Classification of the substance or mixture

##### GHS-US classification

Flam. Liq. 2  
 Skin Irrit. 2  
 Repr. 2  
 STOT RE 2

#### 2.2. GHS Label elements, including precautionary statements

##### GHS-US labeling

Hazard pictograms (GHS-US) :



Signal word (GHS-US) :

Danger

Hazard statements (GHS-US) :

Highly flammable liquid and vapor  
 Causes skin irritation  
 Suspected of damaging fertility or the unborn child  
 May cause damage to organs through prolonged or repeated exposure

Precautionary statements (GHS-US) :

Obtain special instructions before use  
 Do not handle until all safety precautions have been read and understood.  
 Keep away from heat/sparks/open flames/hot surfaces. - No smoking  
 Keep container tightly closed  
 Ground/Bond container and receiving equipment  
 Use explosion-proof electrical/ventilating/lighting equipment  
 Use only non-sparking tools  
 Take precautionary measures against static discharge  
 Do not breathe dust/fume/gas/mist/vapors/spray  
 Wash hands, forearms and face thoroughly after handling  
 Wear protective gloves/protective clothing/eye protection/face protection  
 If exposed or concerned: Get medical advice/attention  
 If on skin (or hair): Take off immediately all contaminated clothing. Rinse skin with water/shower  
 Take off contaminated clothing and wash it before reuse

# Lexel White

## Safety Data Sheet

according to the Hazard Communication Standard (CFR29 1910.1200) HazCom 2012.

If skin irritation occurs: Get medical advice/attention  
Store in a well-ventilated place. Keep cool  
Store locked up  
Dispose of contents/container to hazardous or special waste collection point, in accordance with local, regional, national and/or international regulation

### 2.3. Other hazards which do not result in classification

No additional information available

### 2.4. Unknown acute toxicity (GHS US)

Not applicable

## SECTION 3: Composition/Information on ingredients

### 3.1. Substances

Not applicable

### 3.2. Mixtures

Name	Product identifier	%
Naphtha, petroleum, hydrotreated light	(CAS-No.) 64742-49-0	15 - 40
Toluene	(CAS-No.) 108-88-3	7 - 13
Titanium dioxide	(CAS-No.) 13463-67-7	0.5 - 1.5

\*Chemical name, CAS number and/or exact concentration have been withheld as a trade secret

## SECTION 4: First-aid measures

### 4.1. Description of first aid measures

- First-aid measures after inhalation : If breathing is difficult, remove victim to fresh air and keep at rest in a position comfortable for breathing. Get medical advice/attention if you feel unwell.
- First-aid measures after skin contact : IF ON SKIN: Wash with citrus based cleaner followed by washing with soap and water. Take off contaminated clothing and wash it before reuse. If skin irritation occurs: Get medical advice/attention.
- First-aid measures after eye contact : IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. If eye irritation persists: Get medical advice/attention.
- First-aid measures after ingestion : Do not induce vomiting without medical advice. Never give anything by mouth to an unconscious person. Get medical advice/attention if you feel unwell.

### 4.2. Most important symptoms and effects (acute and delayed)

- Symptoms/effects after inhalation : May cause irritation to the respiratory tract.
- Symptoms/effects after skin contact : Causes skin irritation. Symptoms may include redness, drying, defatting and cracking of the skin.
- Symptoms/effects after eye contact : May cause eye irritation. Symptoms may include discomfort or pain, excess blinking and tear production, with marked redness and swelling of the conjunctiva.
- Symptoms/effects after ingestion : May be harmful if swallowed. May cause gastrointestinal irritation, nausea, vomiting and diarrhea.

### 4.3. Immediate medical attention and special treatment, if necessary

Symptoms may be delayed. In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).

## SECTION 5: Fire-fighting measures

### 5.1. Suitable (and unsuitable) extinguishing media

- Suitable extinguishing media : Use extinguishing media appropriate for surrounding fire. Dry chemical. Carbon dioxide. Foam.
- Unsuitable extinguishing media : Water may be ineffective for extinguishing fire.

### 5.2. Specific hazards arising from the chemical

- Fire hazard : Highly flammable liquid and vapor. Products of combustion may include, and are not limited to: oxides of carbon.
- Explosion hazard : May form flammable/explosive vapor-air mixture.
- Reactivity : No dangerous reactions known under normal conditions of use.

### 5.3. Special protective equipment and precautions for fire-fighters

- Protection during firefighting : Keep upwind of fire. Wear full fire fighting turn-out gear (full Bunker gear) and respiratory protection (SCBA). Use water spray or fog for cooling exposed containers.

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### SECTION 6: Accidental release measures

#### 6.1. Personal precautions, protective equipment and emergency procedures

General measures : Use personal protection recommended in Section 8. Isolate the hazard area and deny entry to unnecessary and unprotected personnel. Use special care to avoid static electric charges. Remove all sources of ignition.

##### 6.1.1. For non-emergency personnel

No additional information available

##### 6.1.2. For emergency responders

No additional information available

#### 6.2. Environmental precautions

Prevent entry to sewers and public waters.

#### 6.3. Methods and material for containment and cleaning up

For containment : Absorb and/or contain spill with inert material (sand, vermiculite or other appropriate material), then place in suitable container. Do not flush into surface water or sewer system. Wear recommended personal protective equipment.

Methods for cleaning up : Sweep or shovel spills into appropriate container for disposal. Provide ventilation.

#### 6.4. Reference to other sections

For further information refer to section 8: "Exposure controls/personal protection"

### SECTION 7: Handling and storage

#### 7.1. Precautions for safe handling

Additional hazards when processed : Handle empty containers with care because residual vapors are flammable.

Precautions for safe handling : Keep away from heat, hot surfaces, sparks, open flames and other ignition sources. No smoking. Obtain special instructions before use. Do not handle until all safety precautions have been read and understood. Avoid contact with skin, eyes and clothing. Do not breathe dust, fume, gas, mist, spray, vapors. Do not swallow. Handle and open container with care. Take precautionary measures against static discharge. Use non-sparking tools.

Hygiene measures : Wash contaminated clothing before reuse. Always wash hands after handling the product.

#### 7.2. Conditions for safe storage, including any incompatibilities

Technical measures : Proper grounding procedures to avoid static electricity should be followed.

Storage conditions : Keep out of the reach of children. Keep container tightly closed in a cool, well-ventilated place. Protect from moisture. Keep away from ignition sources. Store locked up.

### SECTION 8: Exposure controls/personal protection

#### 8.1. Control parameters

Naphtha, petroleum, hydrotreated light (64742-49-0)		
Not applicable		
Toluene (108-88-3)		
ACGIH	ACGIH TWA (ppm)	20 ppm
OSHA	OSHA PEL (TWA) (ppm)	200 ppm
OSHA	OSHA PEL (Ceiling) (ppm)	300 ppm
OSHA	Acceptable maximum peak above the acceptable ceiling concentration for an 8-hr shift	500 ppm Peak (10 minutes)
IDLH	US IDLH (ppm)	500 ppm
NIOSH	NIOSH REL (TWA) (mg/m <sup>3</sup> )	375 mg/m <sup>3</sup>
NIOSH	NIOSH REL (TWA) (ppm)	100 ppm
NIOSH	NIOSH REL (STEL) (mg/m <sup>3</sup> )	560 mg/m <sup>3</sup>
NIOSH	NIOSH REL (STEL) (ppm)	150 ppm
Titanium dioxide (13463-67-7)		
ACGIH	Local name	Titanium dioxide
ACGIH	ACGIH TWA (mg/m <sup>3</sup> )	10 mg/m <sup>3</sup>



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Titanium dioxide (13463-67-7)		
ACGIH	Remark (ACGIH)	LRT irr; A3 (Confirmed Animal Carcinogen with Unknown Relevance to Humans: The agent is carcinogenic in experimental animals at a relatively high dose, by route(s) of administration, at site(s), of histologic type(s), or by mechanism(s) that may not be relevant to worker exposure. Available epidemiologic studies do not confirm an increased risk of cancer in exposed humans. Available evidence does not suggest that the agent is likely to cause cancer in humans except under uncommon or unlikely routes or levels of exposure)
ACGIH	Regulatory reference	ACGIH 2017
OSHA	OSHA PEL (TWA) (mg/m <sup>3</sup> )	15 mg/m <sup>3</sup> (total dust)
OSHA	Regulatory reference (US-OSHA)	OSHA
IDLH	US IDLH (mg/m <sup>3</sup> )	5000 mg/m <sup>3</sup>

### 8.2. Appropriate engineering controls

Appropriate engineering controls : Ensure good ventilation of the work station.  
Environmental exposure controls : Avoid release to the environment.

### 8.3. Individual protection measures/Personal protective equipment

#### Hand protection:

Wear suitable gloves resistant to chemical penetration

#### Eye protection:

Safety glasses or goggles are recommended when using product.

#### Skin and body protection:

Wear suitable protective clothing

#### Respiratory protection:

In case of insufficient ventilation, wear suitable respiratory equipment. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator.

#### Other information:

Handle in accordance with good industrial hygiene and safety procedures. Do not eat, drink or smoke when using this product.

## SECTION 9: Physical and chemical properties

### 9.1. Information on basic physical and chemical properties

Physical state : Liquid  
Appearance : Paste  
Color : White  
Odor : Solvent  
Odor threshold : No data available  
pH : No data available  
Melting point : No data available  
Freezing point : No data available  
Boiling point : No data available  
Flash point : 48 °F / 8.9 °C [ASTM D-93]  
Relative evaporation rate (butyl acetate=1) : No data available  
Flammability (solid, gas) : Highly flammable liquid and vapor  
Vapor pressure : No data available  
Relative vapor density at 20 °C : No data available  
Relative density : 0.89  
Solubility : No data available  
Partition coefficient n-octanol/water : No data available

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Auto-ignition temperature	: No data available
Decomposition temperature	: No data available
Viscosity, kinematic	: No data available
Viscosity, dynamic	: 214000 cP @ 10 rpm / 77 °F
Explosion limits	: No data available
Explosive properties	: No data available
Oxidizing properties	: No data available

### 9.2. Other information

No additional information available

## SECTION 10: Stability and reactivity

### 10.1. Reactivity

No dangerous reactions known under normal conditions of use.

### 10.2. Chemical stability

Stable under normal conditions. May form flammable/explosive vapor-air mixture.

### 10.3. Possibility of hazardous reactions

No dangerous reactions known under normal conditions of use.

### 10.4. Conditions to avoid

Sources of ignition. Heat. Incompatible materials.

### 10.5. Incompatible materials

Strong oxidizing agents.

### 10.6. Hazardous decomposition products

May include, and are not limited to: oxides of carbon. May release flammable gases.

## SECTION 11: Toxicological information

### 11.1. Information on toxicological effects

Acute toxicity : Not classified

Naphtha, petroleum, hydrotreated light (64742-49-0)	
LD50 oral rat	> 5000 mg/kg
LD50 dermal rabbit	> 3160 mg/kg
LC50 inhalation rat	73680 ppm/4h
Toluene (108-88-3)	
LD50 oral rat	2600 mg/kg
LD50 dermal rabbit	12000 mg/kg
LC50 inhalation rat	12.5 mg/l/4h
Titanium dioxide (13463-67-7)	
LD50 oral rat	> 10000 mg/kg

Skin corrosion/irritation	: Causes skin irritation.
Serious eye damage/irritation	: Not classified
Respiratory or skin sensitization	: Not classified
Germ cell mutagenicity	: Not classified
Carcinogenicity	: Not classified

Toluene (108-88-3)	
IARC group	3 - Not classifiable

Reproductive toxicity	: Suspected of damaging fertility or the unborn child.
Specific target organ toxicity – single exposure	: Not classified
Specific target organ toxicity – repeated exposure	: May cause damage to organs through prolonged or repeated exposure.
Aspiration hazard	: Not classified
Symptoms/effects after inhalation	: May cause irritation to the respiratory tract.
Symptoms/effects after skin contact	: Causes skin irritation. Symptoms may include redness, drying, defatting and cracking of the skin.

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Symptoms/effects after eye contact	: May cause eye irritation. Symptoms may include discomfort or pain, excess blinking and tear production, with marked redness and swelling of the conjunctiva.
Symptoms/effects after ingestion	: May be harmful if swallowed. May cause gastrointestinal irritation, nausea, vomiting and diarrhea.
Other information	: Likely routes of exposure: ingestion, inhalation, skin and eye.

### SECTION 12: Ecological information

#### 12.1. Toxicity

Ecology - general : May cause long-term adverse effects in the aquatic environment.

#### 12.2. Persistence and degradability

No additional information available

#### 12.3. Bioaccumulative potential

No additional information available

#### 12.4. Mobility in soil

No additional information available

#### 12.5. Other adverse effects

No additional information available

### SECTION 13: Disposal considerations

#### 13.1. Disposal methods

Product/Packaging disposal recommendations	: Dispose of contents/container in accordance with local, regional, national and/or international regulation.
Additional information	: Handle empty containers with care because residual vapors are flammable.

### SECTION 14: Transport information

#### Department of Transportation (DOT)

In accordance with DOT

UN-No.(DOT)	: UN1133
Proper Shipping Name (DOT)	: Adhesives
Class (DOT)	: 3 - Class 3 - Flammable and combustible liquid 49 CFR 173.120
Packing group (DOT)	: III (As per 173.121(b) exemption)
Hazard labels (DOT)	:



Proper Shipping Name (DOT)	: Consumer commodity
Class (DOT)	: ORM-D - ORM-D – Other regulated materials for domestic transport only
Hazard labels (DOT) LTD QTY - Limited quantity	:



#### Transport by sea

Transport document description (IMDG)	: UN 1133 ADHESIVES, 3, III
UN-No. (IMDG)	: 1133
Proper Shipping Name (IMDG)	: ADHESIVES
Class (IMDG)	: 3 - Flammable liquids
Packing group (IMDG)	: III - substances presenting low danger
Limited quantities (IMDG)	: 5 L

#### Air transport

Transport document description (IATA)	: UN 1133 Adhesives, 3, III
---------------------------------------	-----------------------------

# Lexel White

## Safety Data Sheet

according to the Hazard Communication Standard (CFR29 1910.1200) HazCom 2012.

UN-No. (IATA)	: 1133
Proper Shipping Name (IATA)	: Adhesives
Class (IATA)	: 3 - Flammable Liquids
Packing group (IATA)	: III - Minor Danger
Limited quantities (IATA)	: 10 L

### SECTION 15: Regulatory information

#### 15.1. US Federal regulations

No additional information available

#### 15.2. International regulations

No additional information available

#### 15.3. US State regulations

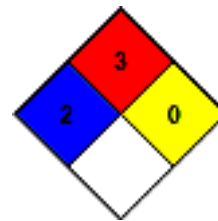
 **WARNING:** Reproductive Harm - [www.P65Warnings.ca.gov](http://www.P65Warnings.ca.gov).

### SECTION 16: Other information

Date of issue	: 09/25/2017
Revision date	: 08/23/2018
Other information	: None.
Prepared by	: Nexreg Compliance Inc. <a href="http://www.Nexreg.com">www.Nexreg.com</a>



NFPA health hazard	: 2 - Materials that, under emergency conditions, can cause temporary incapacitation or residual injury.
NFPA fire hazard	: 3 - Liquids and solids (including finely divided suspended solids) that can be ignited under almost all ambient temperature conditions.
NFPA reactivity	: 0 - Material that in themselves are normally stable, even under fire conditions.



HMIS Hazard Rating	
Health	: 2 Moderate Hazard - Temporary or minor injury may occur
Flammability	: 3 Serious Hazard - Materials capable of ignition under almost all normal temperature conditions. Includes flammable liquids with flash points below 73 F and boiling points above 100 F. as well as liquids with flash points between 73 F and 100 F. (Classes IB & IC)
Physical	: 0 Minimal Hazard - Materials that are normally stable, even under fire conditions, and will NOT react with water, polymerize, decompose, condense, or self-react. Non-Explosives.
Personal protection	: B - Safety glasses, Gloves

SDS US (GHS HazCom 2012)\_NEXREG\_NEW

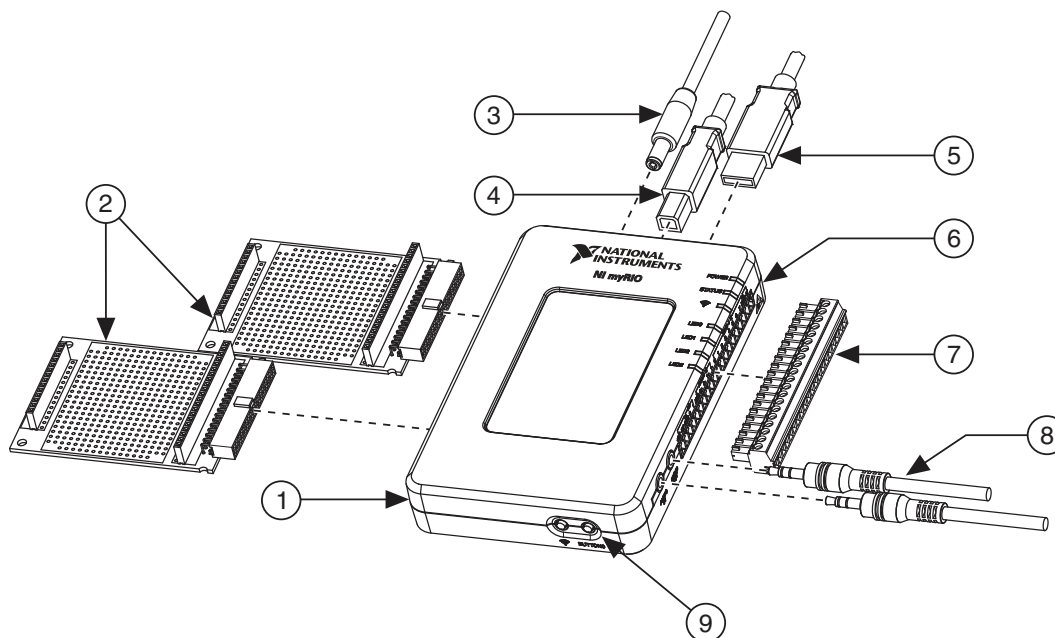
*Disclaimer: We believe the statements, technical information and recommendations contained herein are reliable, but they are given without warranty or guarantee of any kind. The information contained in this document applies to this specific material as supplied. It may not be valid for this material if it is used in combination with any other materials. It is the user's responsibility to satisfy oneself as to the suitability and completeness of this information for the user's own particular use.*

# USER GUIDE AND SPECIFICATIONS

## NI myRIO-1900

The National Instruments myRIO-1900 is a portable reconfigurable I/O (RIO) device that students can use to design control, robotics, and mechatronics systems. This document contains pinouts, connectivity information, dimensions, mounting instructions, and specifications for the NI myRIO-1900.

**Figure 1.** NI myRIO-1900



- |  |   |
|--|---|
| 1 NI myRIO-1900  | 6 LEDs  |
| 2 myRIO Expansion Port (MXP) Breakouts (One Included in Kit) | 7 Mini System Port (MSP) Screw-Terminal Connector |
| 3 Power Input Cable  | 8 Audio In/Out Cables (One Included in Kit)       |
| 4 USB Device Cable   | 9 Button0   |
| 5 USB Host Cable (Not Included in Kit)                       |   |

# Safety Information

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**Caution** Do not operate the hardware in a manner not specified in this document and in the user documentation. Misuse of the hardware can result in a hazard. You can compromise the safety protection if the hardware is damaged in any way. If the hardware is damaged, return it to National Instruments for repair.

Clean the hardware with a soft, nonmetallic brush. Make sure that the hardware is completely dry and free from contaminants before returning it to service.

## Electromagnetic Compatibility Guidelines

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This product was tested and complies with the regulatory requirements and limits for electromagnetic compatibility (EMC) stated in the product specifications. These requirements and limits provide reasonable protection against harmful interference when the product is operated in the intended operational electromagnetic environment.

This product is intended for use in commercial locations. There is no guarantee that harmful interference will not occur in a particular installation or when the product is connected to a test object. To minimize interference with radio and television reception and prevent unacceptable performance degradation, install and use this product in strict accordance with the instructions in the product documentation.

Furthermore, any modifications to the product not expressly approved by National Instruments could void your authority to operate it under your local regulatory rules.



**Caution** This product was tested for EMC compliance using myRIO application software. The maximum length for USB cables is 2.0 m (6.6 ft), and the maximum length for signal wires is 30.0 cm (11.8 in.).



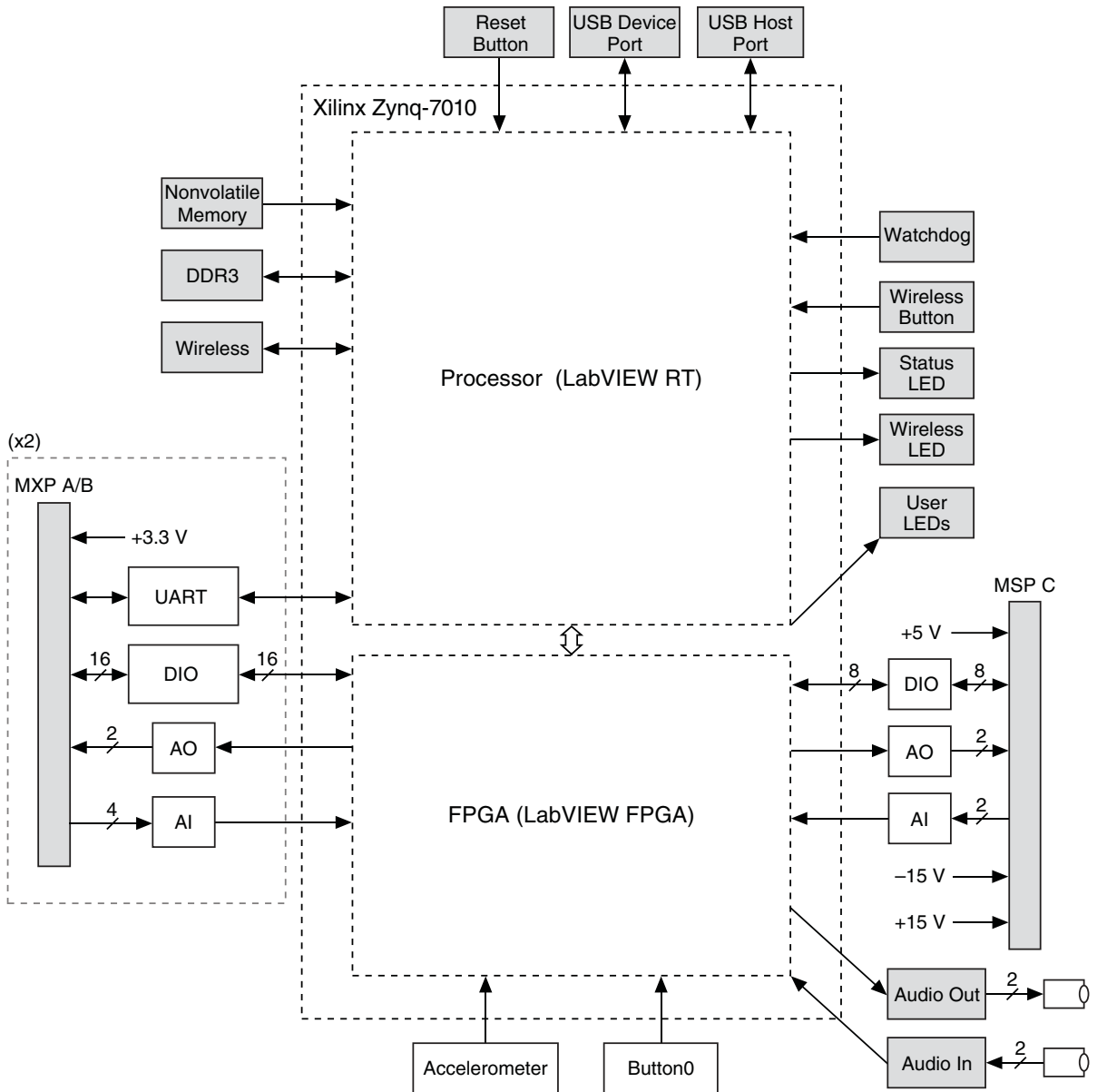
**Caution** The mounting keyholes on the back of the NI myRIO-1900 are sensitive to electrostatic discharge (ESD). When handling the device, be careful not to touch inside the keyholes.

# Hardware Overview

The NI myRIO-1900 provides analog input (AI), analog output (AO), digital input and output (DIO), audio, and power output in a compact embedded device. The NI myRIO-1900 connects to a host computer over USB and wireless 802.11b,g,n.

The following figure shows the arrangement and functions of NI myRIO-1900 components.

**Figure 2.** NI myRIO-1900 Hardware Block Diagram





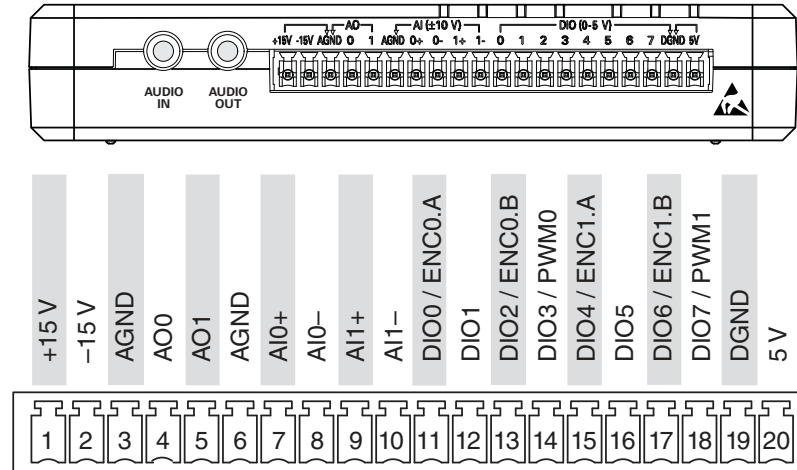


**Table 1.** Descriptions of Signals on MXP Connectors A and B

Signal Name	Reference	Direction	Description
+5V	DGND	Output	+5 V power output.
AI <0..3>	AGND	Input	0-5 V, referenced, single-ended analog input channels. Refer to the <i>Analog Input Channels</i> section for more information.
AO <0..1>	AGND	Output	0-5 V referenced, single-ended analog output. Refer to the <i>Analog Output Channels</i> section for more information.
AGND	N/A	N/A	Reference for analog input and output.
+3.3V	DGND	Output	+3.3 V power output.
DIO <0..15>	DGND	Input or Output	General-purpose digital lines with 3.3 V output, 3.3 V/5 V-compatible input. Refer to the <i>DIO Lines</i> section for more information.
UART.RX	DGND	Input	UART receive input. UART lines are electrically identical to DIO lines.
UART.TX	DGND	Output	UART transmit output. UART lines are electrically identical to DIO lines.
DGND	N/A	N/A	Reference for digital signals, +5 V, and +3.3 V.

The following figure and table show the signals on Mini System Port (MSP) connector C. Note that some pins carry secondary functions as well as primary functions.

**Figure 4.** Primary/Secondary Signals on MSP Connector C



**Table 2.** Descriptions of Signals on MSP Connector C

Signal Name	Reference	Direction	Description
+15V/-15V	AGND	Output	+15 V/-15 V power output.
AI0+/AI0-; AI1+/AI1-	AGND	Input	$\pm 10$ V, differential analog input channels. Refer to the <a href="#">Analog Input Channels</a> section for more information.
AO <0..1>	AGND	Output	$\pm 10$ V referenced, single-ended analog output channels. Refer to the <a href="#">Analog Output Channels</a> section for more information.
AGND	N/A	N/A	Reference for analog input and output and +15 V/-15 V power output.
+5V	DGND	Output	+5 V power output.
DIO <0..7>	DGND	Input or Output	General-purpose digital lines with 3.3 V output, 3.3 V/5 V-compatible input. Refer to the <a href="#">DIO Lines</a> section for more information.
DGND	N/A	N/A	Reference for digital lines and +5 V power output.

**Table 3.** Descriptions of Signals on Audio Connectors

Signal Name	Reference	Direction	Description
AUDIO IN	N/A	Input	Left and right audio inputs on stereo connector.
AUDIO OUT	N/A	Output	Left and right audio outputs on stereo connector.

## Analog Input Channels

The NI myRIO-1900 has analog input channels on myRIO Expansion Port (MXP) connectors A and B, Mini System Port (MSP) connector C, and a stereo audio input connector. The analog inputs are multiplexed to a single analog-to-digital converter (ADC) that samples all channels.

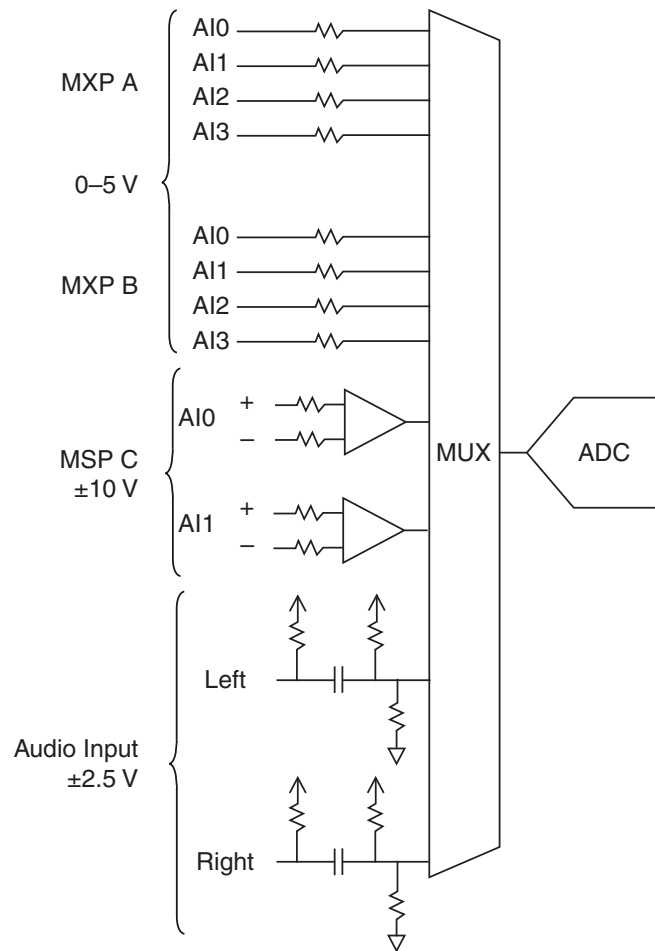
MXP connectors A and B have four single-ended analog input channels per connector, AI0-AI3, which you can use to measure 0-5 V signals. MSP connector C has two high-impedance, differential analog input channels, AI0 and AI1, which you can use to measure signals up to  $\pm 10$  V. The audio inputs are left and right stereo line-level inputs with a  $\pm 2.5$  V full-scale range.



**Note** For important information about improving measurement accuracy by reducing noise, go to [ni.com/info](http://ni.com/info) and enter the Info Code `analogwiring`.

Figure 5 shows the analog input topology of the NI myRIO-1900.

**Figure 5.** NI myRIO-1900 Analog Input Circuitry



## Analog Output Channels

The NI myRIO-1900 has analog output channels on myRIO Expansion Port (MXP) connectors A and B, Mini System Port (MSP) connector C, and a stereo audio output connector. Each analog output channel has a dedicated digital-to-analog converter (DAC), so they can all update simultaneously. The DACs for the analog output channels are controlled by two serial communication buses from the FPGA. MXP connectors A and B share one bus, and MSP connector C and the audio outputs share a second bus. Therefore, the maximum update rate is specified as an aggregate figure in the [Analog Output](#) section of the [Specifications](#).

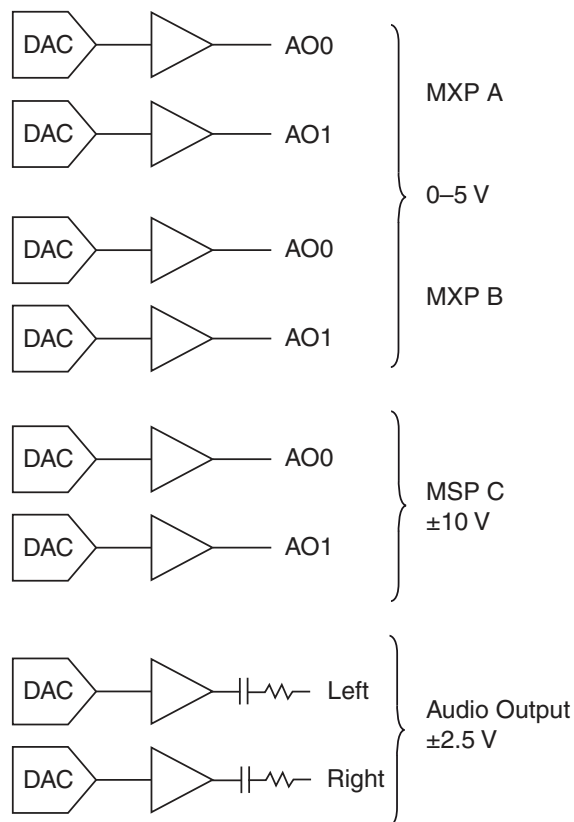
MXP connectors A and B have two analog output channels per connector, AO0 and AO1, which you can use to generate 0-5 V signals. MSP connector C has two analog output channels, AO0 and AO1, which you can use to generate signals up to  $\pm 10$  V. The audio outputs are left and right stereo line-level outputs capable of driving headphones.



**Caution** Before using headphones to listen to the audio output of the NI myRIO-1900, ensure that the audio output is at a safe level. Listening to audio signals at a high volume may result in permanent hearing loss.

Figure 6 shows the analog output topology of the NI myRIO-1900.

**Figure 6.** NI myRIO-1900 Analog Output Circuitry



## Accelerometer

The NI myRIO-1900 contains a three-axis accelerometer. The accelerometer samples each axis continuously and updates a readable register with the result. Refer to the [Accelerometer](#) section of the [Specifications](#) for the accelerometer sample rates.

# Converting Raw Data Values to Voltage

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You can use the following equations to convert raw data values to volts:

$$V = \text{Raw Data Value} * \text{LSB Weight}$$

$$\text{LSB Weight} = \text{Nominal Range} \div 2^{\text{ADC Resolution}}$$

where *Raw Data Value* is the value returned by the FPGA I/O Node, *LSB Weight* is the value in volts of the increment between data values, *Nominal Range* is the absolute value in volts of the full, peak-to-peak nominal range of the channel, and *ADC Resolution* is the resolution of the ADC in bits. (*ADC Resolution* = 12)

- For AI and AO channels on the MXP connectors,

$$\text{LSB Weight} = 5 \text{ V} \div 2^{12} = 1.221 \text{ mV}$$

$$\text{Maximum reading} = 4095 * 1.221 \text{ mV} = 4.999 \text{ V}$$

- For AI and AO channels on the MSP connectors,

$$\text{LSB Weight} = 20 \text{ V} \div 2^{12} = 4.883 \text{ mV}$$

$$\text{Maximum Positive Reading} = +2047 * 4.883 \text{ mV} = 9.995 \text{ V}$$

$$\text{Maximum Negative Reading} = -2048 * 4.883 \text{ mV} = -10.000 \text{ V}$$

- For Audio In/Out,

$$\text{LSB Weight} = 5 \text{ V} \div 2^{12} = 1.221 \text{ mV}$$

$$\text{Maximum Positive Reading} = +2047 * 1.221 \text{ mV} = 2.499 \text{ V}$$

$$\text{Maximum Negative Reading} = -2048 * 1.221 \text{ mV} = -2.500 \text{ V}$$

- For the accelerometer,

$$\text{LSB Weight} = 16 \text{ g} \div 2^{12} = 3.906 \text{ mg}$$

$$\text{Maximum Positive Reading} = +2047 * 3.906 \text{ mg} = +7.996 \text{ g}$$

$$\text{Maximum Negative Reading} = -2048 * 3.906 \text{ mg} = -8.000 \text{ g}$$

## DIO Lines

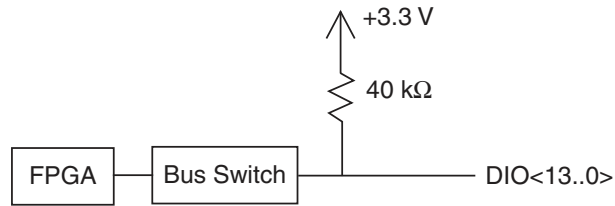
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The NI myRIO-1900 has 3.3 V general-purpose DIO lines on the MXP and MSP connectors. MXP connectors A and B have 16 DIO lines per connector. On the MXP connectors, each DIO line from 0 to 13 has a 40 k $\Omega$  pullup resistor to 3.3 V, and DIO lines 14 and 15 have 2.1 k $\Omega$  pullup resistors to 3.3 V. MSP connector C has eight DIO lines. Each MSP DIO line has a 40 k $\Omega$  pulldown resistor to ground. DGND is the reference for all the DIO lines. You can program all the lines individually as inputs or outputs. Secondary digital functions include Serial Peripheral

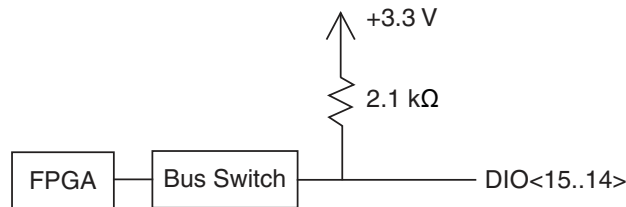


Interface Bus (SPI), I2C, pulse-width modulation (PWM), and quadrature encoder input. Refer to the NI myRIO software documentation for information about configuring the DIO lines.

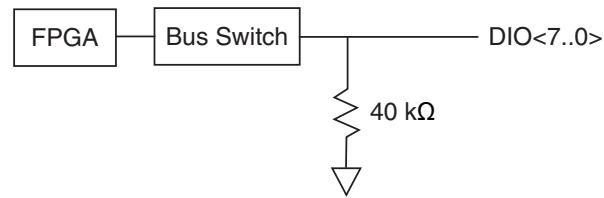
**Figure 7.** DIO Lines <13..0> on MXP Connector A or B



**Figure 8.** DIO Lines <15..14> on MXP Connector A or B



**Figure 9.** DIO Lines <7..0> on MSP Connector C



When a DIO line is floating, it floats in the direction of the pull resistor. A DIO line may be floating in any of the following conditions:

- when the myRIO device is starting up
- when the line is configured as an input
- when the myRIO device is powering down

You can add a stronger resistor to a DIO line to cause it to float in the opposite direction.

## UART Lines

The NI myRIO-1900 has one UART receive input line and one UART transmit output line on each MXP connector. The UART lines are electrically identical to DIO lines 0 to 13 on the MXP connectors. Like those lines, UART.RX and UART.TX have 40 kΩ pullup resistors to 3.3 V. Use LabVIEW Real-Time to read and write over the UART lines.

# Using the Reset Button

---

Pressing and releasing the Reset button restarts the processor and the FPGA.

Pressing and holding the Reset button for 5 seconds, then releasing it, restarts the processor and the FPGA and forces the NI myRIO-1900 into safe mode. In safe mode, the NI myRIO-1900 launches only the services necessary for updating configuration and installing software.

When the NI myRIO-1900 is in safe mode, you can communicate with it by using the UART lines on MXP connector A. You need the following items to communicate with the myRIO device over UART:

- USB-to-TTL serial UART converter cable (for example, part number TTL-232RG-VSW3V3-WE from FTD Chip)
- Serial-port terminal program configured with the following settings:
  - 115,200 bits per second
  - Eight data bits
  - No parity
  - One stop bit
  - No flow control

# Using the Wireless Button and LED

---

For information about using the Wireless button, go to [ni.com/info](http://ni.com/info) and enter the Info Code `myriowirelessbutton`.

For information about using the Wireless LED, go to [ni.com/info](http://ni.com/info) and enter the Info Code `myriowirelessled`.

# Using Button0

---

Button0 produces a logic TRUE when depressed and a logic FALSE when not depressed. Button0 is not debounced.

# Understanding LED Indications

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## Power LED

The Power LED is lit while the NI myRIO-1900 is powered on. This LED indicates that the power supply connected to the device is adequate.

## Status LED

The Status LED is off during normal operation. The NI myRIO-1900 runs a power-on self test (POST) when you apply power to the device. During the POST, the Power and Status LEDs turn on. When the Status LED turns off, the POST is complete. The NI myRIO-1900 indicates specific error conditions by flashing the Status LED a certain number of times every few seconds, as shown in Table 4.

**Table 4.** Status LED Indications

<b>Number of Flashes Every Few Seconds</b>	<b>Indication</b>
2	The device has detected an error in its software. This usually occurs when an attempt to upgrade the software is interrupted. Reinstall software on the device.
3	The device is in safe mode.
4	The software has crashed twice without rebooting or cycling power between crashes. This usually occurs when the device runs out of memory. Review your RT VI and check the memory usage. Modify the VI as necessary to solve the memory usage issue.
Continuously flashing or solid	The device has detected an unrecoverable error. Contact National Instruments.

## LEDs 0 to 3

You can use LEDs 0 to 3 to help debug your application or easily retrieve application status. Logic TRUE turns an LED on and logic FALSE turns an LED off.

## Using the USB Host Port

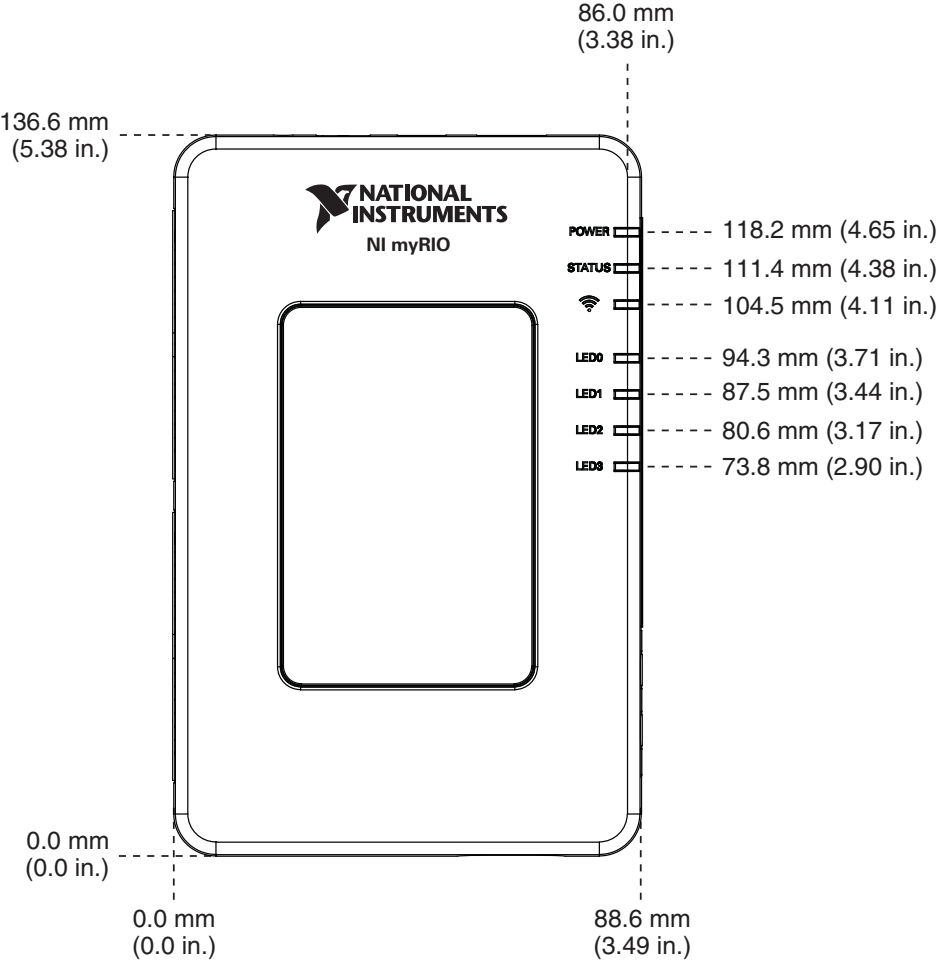
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The NI myRIO-1900 USB host port supports Web cameras that conform to the USB Video Device Class (UVC) protocol as well as machine vision cameras that conform to the USB3 Vision standard and are USB 2.0 backward compatible. The NI myRIO-1900 USB host port also supports Basler ace USB3 cameras.

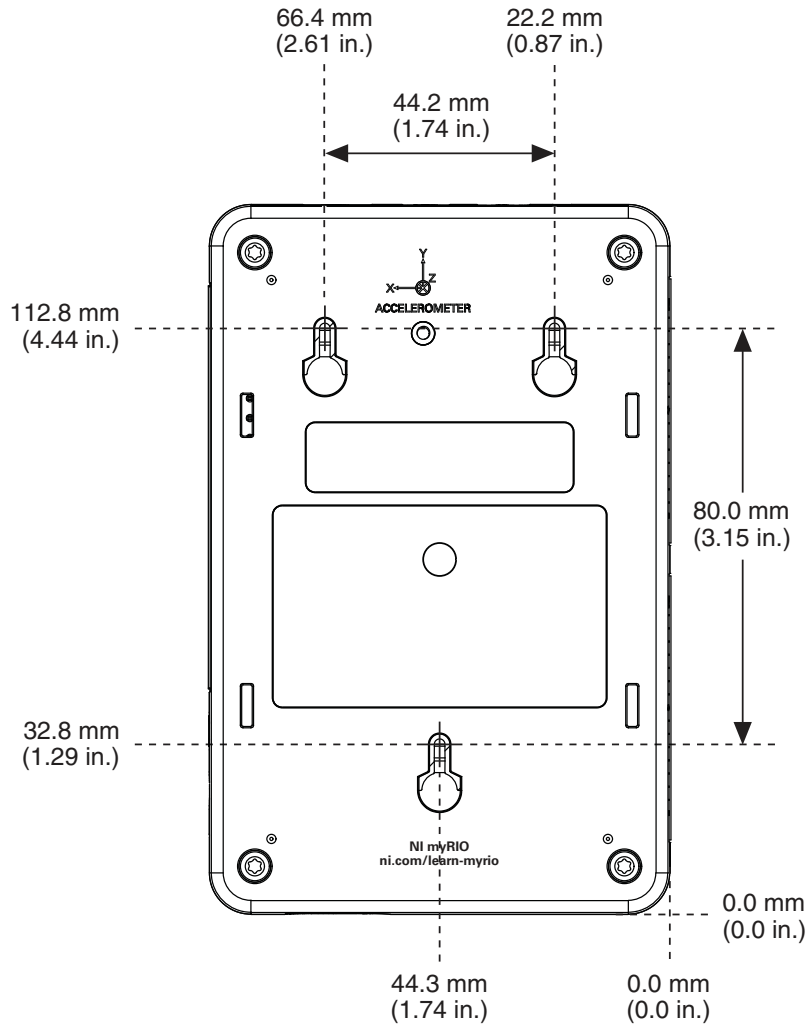
The NI myRIO-1900 USB host port also supports USB Flash drives and USB-to-IDE adapters formatted with FAT16 and FAT32 file systems. LabVIEW usually maps USB devices to the /U, /V, /W, or /X drive, starting with the /U drive if it is available.

# NI myRIO-1900 Physical Dimensions

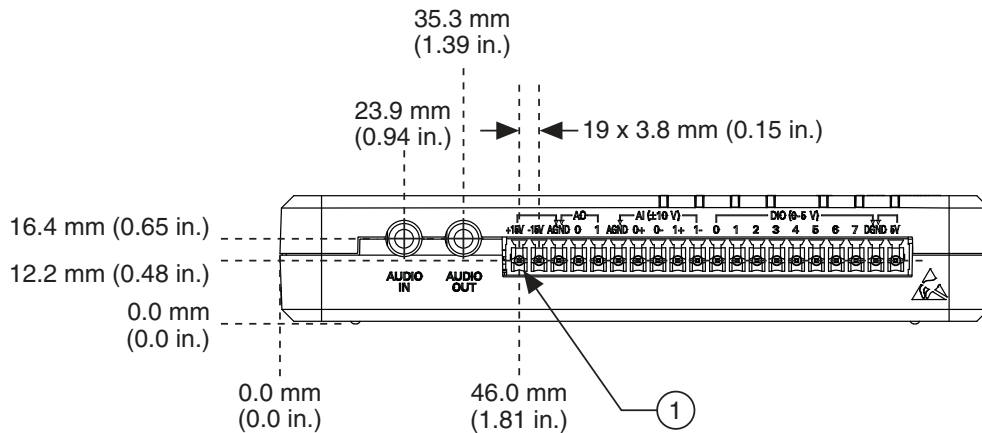
Figure 10. NI myRIO-1900 Dimensions, Front



**Figure 11. NI myRIO-1900 Dimensions, Back**

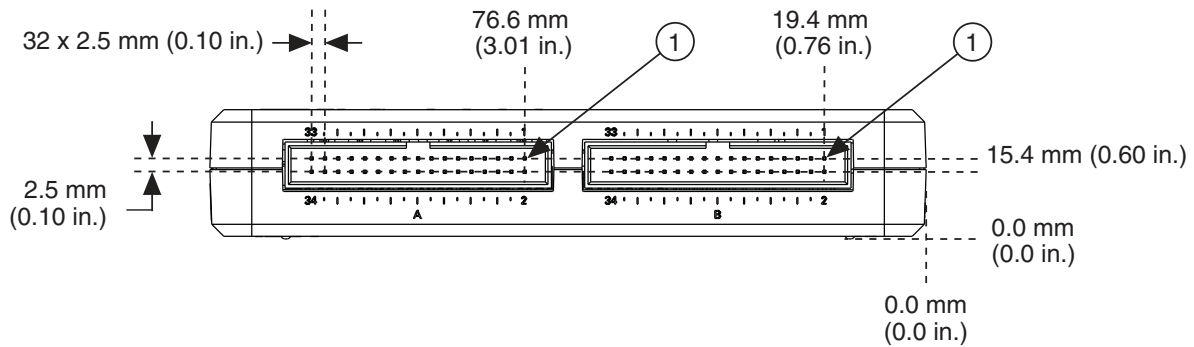


**Figure 12. NI myRIO-1900 Dimensions, MSP Side**



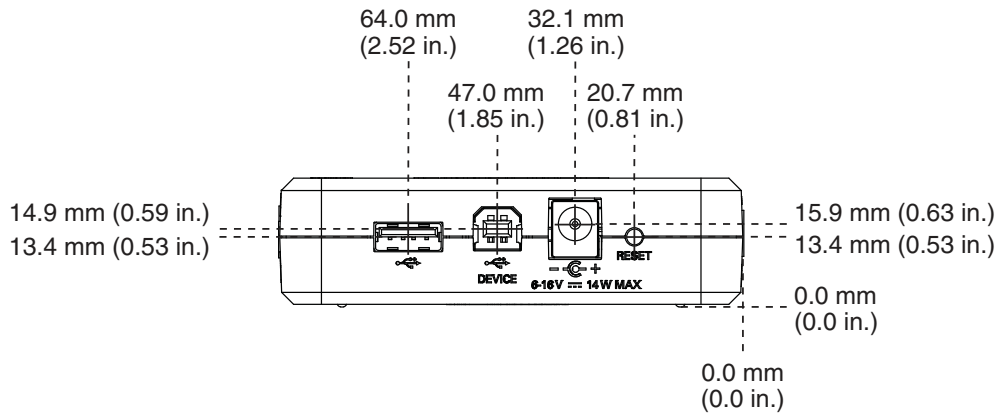
1 Pin 1

**Figure 13. NI myRIO-1900 Dimensions, MXP Side**

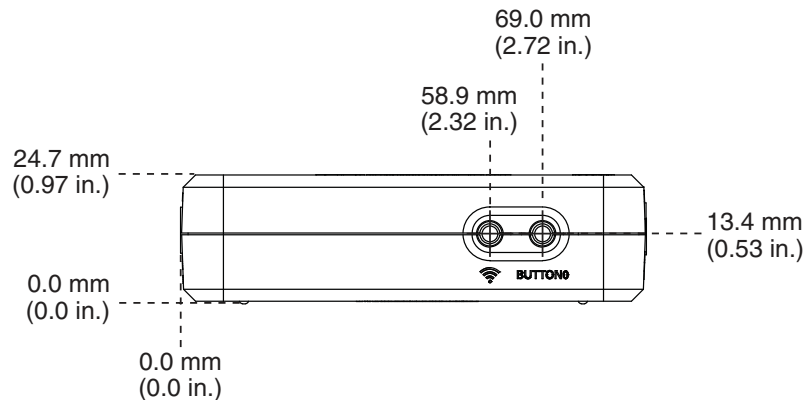


1 Pin 1

**Figure 14. NI myRIO-1900 Dimensions, I/O End**



**Figure 15. NI myRIO-1900 Dimensions, User End**

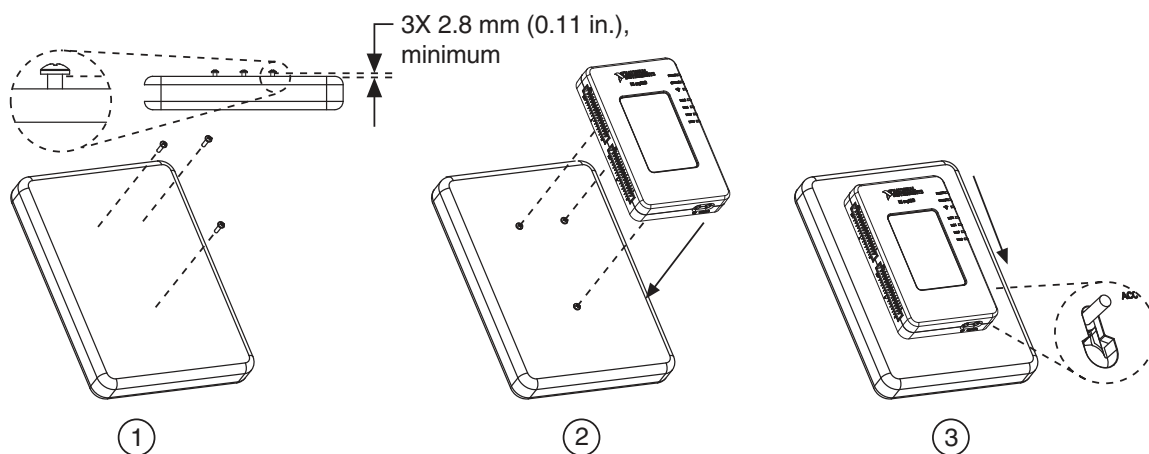


## Mounting the NI myRIO-1900

### Mounting the NI myRIO-1900 Using the Key Holes

You can use the provided key holes on NI myRIO-1900 to mount the device on a flat surface. Install the NI myRIO-1900 as shown in Figure 16. Use Unified #4 or ISO M3 screws to mount the NI myRIO-1900 using the key holes. Panhead screws are suitable for use with the NI myRIO-1900 key holes.

**Figure 16.** Mounting the NI myRIO-1900 Using the Key Holes

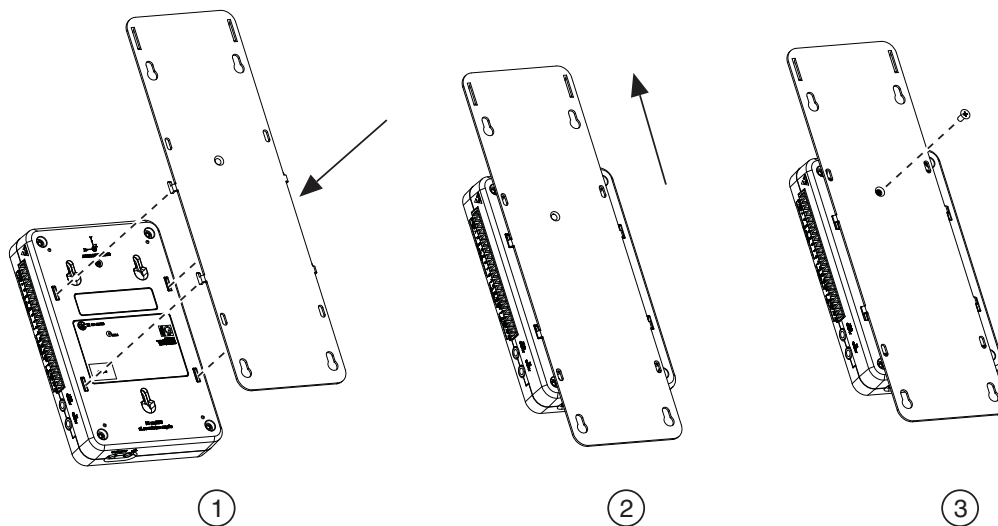


- 1 Install three Unified #4 or M3 screws in the flat surface using the key hole dimensions of the NI myRIO-1900 as a guide. Refer to Figure 11 for NI myRIO-1900 key hole dimensions. Leave a minimum spacing of 2.8 mm (0.11 in.) between the flat surface and the screw heads.
- 2 Place the NI myRIO-1900 on the screw heads.
- 3 Slide the NI myRIO-1900 down to secure the key holes on the screw heads.

## Mounting the NI myRIO-1900 Using the Panel Mounting Kit

You can use the Panel Mounting Kit for NI myRIO-1900 to mount the device on a flat surface such as a panel or wall. Install the panel mounting kit on the NI myRIO-1900 as shown in Figure 17.

**Figure 17.** Installing the Panel Mounting Kit on the NI myRIO-1900

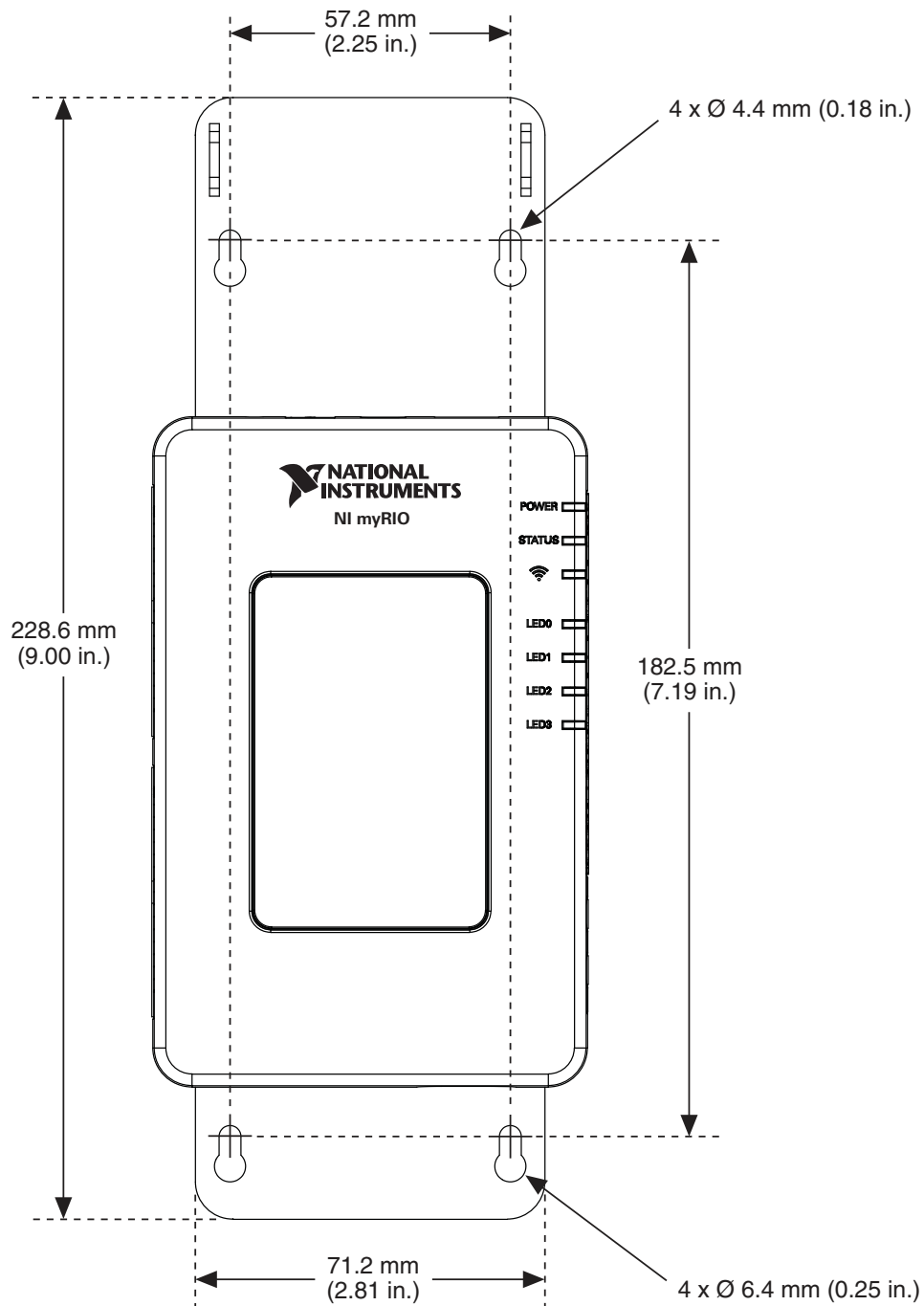


- 1 Place the panel on the back of the NI myRIO-1900
- 2 Slide the panel up to line up the screw holes on the panel and the NI myRIO-1900.
- 3 Secure the panel to the NI myRIO-1900. You must use the included 4-40 x 1/4 in. screw to attach the panel mounting kit to the NI myRIO-1900. Tighten the screw to 0.76 N · m (6.7 lb · in.) of torque. Do not exceed 0.87 N · m (7.7 lb · in.) of torque.



Fasten the panel mounting kit to the panel or wall using screws appropriate for the surface. The following figure shows the dimensions of the NI myRIO-1900 with the panel mounting kit installed.

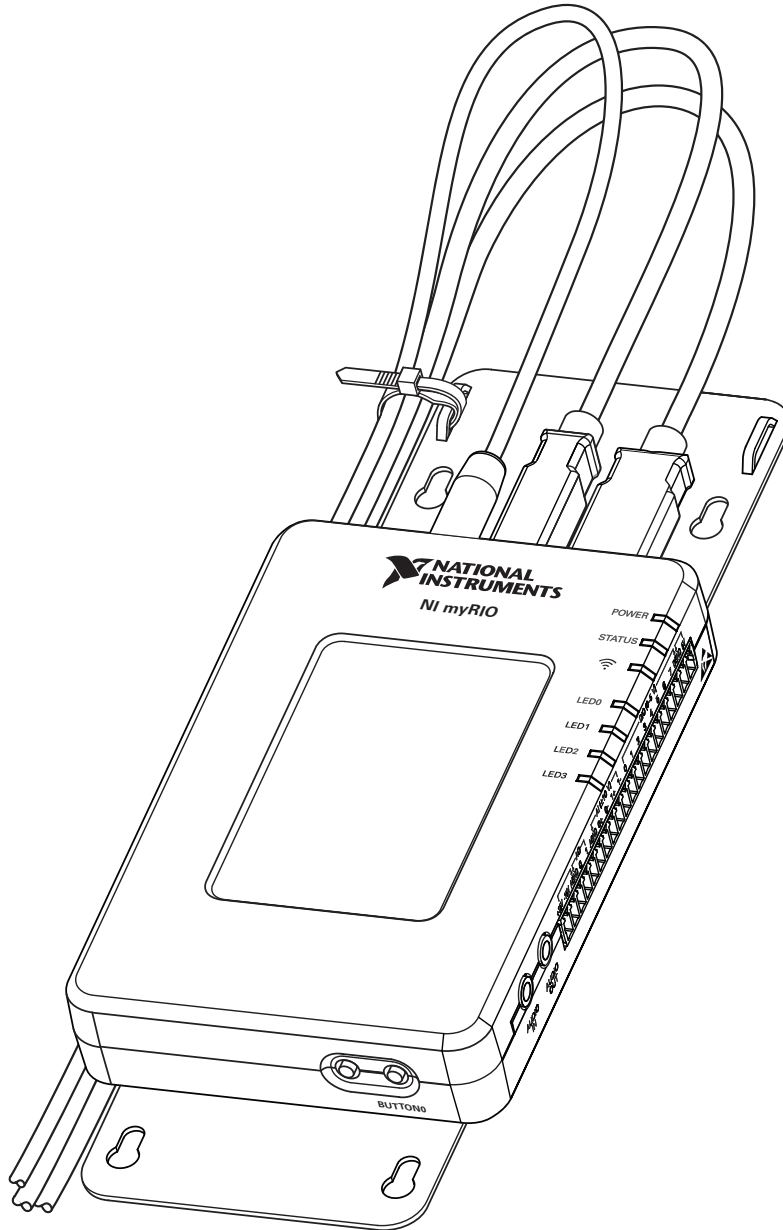
**Figure 18.** Dimensions of NI myRIO-1900 with Panel Mounting Kit



Use a cable tie to secure the power and USB cables to the panel mounting kit as shown in Figure 19.

**Figure 19.** Securing the Power and USB Cables to the Panel Mounting Kit

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# Cables and Accessories

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**Table 5.** Accessories Available from NI

<b>Accessory</b>	<b>Description</b>	<b>NI Part Number</b>
Power supply	Power supply for NI myRIO-1900	723403-01
MXP breakouts	Set of five MXP breakout boards for NI myRIO-1900	782696-01
MSP connector	MSP replacement connector plug for NI myRIO-1900	765788-01
Panel mounting kit	Panel mounting kit for NI myRIO-1900	783091-01

## Specifications

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The following specifications are typical for the 0 to 40 °C operating temperature range unless otherwise noted.

### Processor

Processor type ..... Xilinx Z-7010  
Processor speed ..... 667 MHz  
Processor cores ..... 2

### Memory

Nonvolatile memory ..... 512 MB  
DDR3 memory ..... 256 MB  
    DDR3 clock frequency ..... 533 MHz  
    DDR3 data bus width ..... 16 bits

For information about the lifespan of the nonvolatile memory and about best practices for using nonvolatile memory, go to [ni.com/info](http://ni.com/info) and enter the Info Code SSDBP.

### FPGA

FPGA type ..... Xilinx Z-7010

### Wireless Characteristics

Radio mode ..... IEEE 802.11 b,g,n  
Frequency band ..... ISM 2.4 GHz  
Channel width ..... 20 MHz

Channels .....	USA 1 to 11, International 1 to 13
TX power .....	+10 dBm max (10 mW)
Outdoor range .....	Up to 150 m (line of sight)
Antenna directivity .....	Omnidirectional
Security .....	WPA, WPA2, WPA2-Enterprise

## USB Ports

USB host port .....	USB 2.0 Hi-Speed
USB device port.....	USB 2.0 Hi-Speed

## Analog Input

Aggregate sample rate .....	500 kS/s
Resolution .....	12 bits
Overvoltage protection .....	$\pm 16$ V

### MXP connectors

Configuration.....	Four single-ended channels per connector
Input impedance .....	>500 k $\Omega$ acquiring at 500 kS/s 1 M $\Omega$ powered on and idle 4.7 k $\Omega$ powered off
Recommended source impedance .....	3 k $\Omega$ or less
Nominal range .....	0 V to +5 V
Absolute accuracy.....	$\pm 50$ mV
Bandwidth.....	>300 kHz

### MSP connector

Configuration.....	Two differential channels
Input impedance .....	Up to 100 nA leakage powered on; 4.7 k $\Omega$ powered off
Nominal range .....	$\pm 10$ V
Working voltage (signal + common mode).....	$\pm 10$ V of AGND
Absolute accuracy.....	$\pm 200$ mV
Bandwidth.....	20 kHz minimum, >50 kHz typical

### Audio input

Configuration.....	One stereo input consisting of two AC-coupled, single-ended channels
Input impedance .....	10 k $\Omega$ at DC
Nominal range .....	$\pm 2.5$ V
Bandwidth.....	2 Hz to >20 kHz

# Analog Output

## Aggregate maximum update rates

All AO channels on MXP connectors.....	345 kS/s
All AO channels on MSP connector and audio output channels.....	345 kS/s

Resolution ..... 12 bits

Overload protection .....  $\pm 16$  V

Startup voltage ..... 0 V after FPGA initialization

## MXP connectors

Configuration.....	Two single-ended channels per connector
Range.....	0 V to +5 V
Absolute accuracy.....	50 mV
Current drive.....	3 mA
Slew rate.....	0.3 V/ $\mu$ s

## MSP connector

Configuration.....	Two single-ended channels
Range.....	$\pm 10$ V
Absolute accuracy.....	$\pm 200$ mV
Current drive.....	2 mA
Slew rate.....	2 V/ $\mu$ s

## Audio output

Configuration.....	One stereo output consisting of two AC-coupled, single-ended channels
Output impedance.....	100 $\Omega$ in series with 22 $\mu$ F
Bandwidth.....	70 Hz to >50 kHz into 32 $\Omega$ load; 2 Hz to >50 kHz into high-impedance load

# Digital I/O

## Number of lines

MXP connectors ..... 2 ports of 16 DIO lines (one port per connector);  
one UART.RX and one UART.TX line per  
connector

MSP connector..... 1 port of 8 DIO lines

Direction control..... Each DIO line individually programmable as  
input or output

Logic level..... 5 V compatible LVTTTL input; 3.3 V LVTTTL  
output

## Input logic levels

Input low voltage, $V_{IL}$ .....	0 V min; 0.8 V max
Input high voltage, $V_{IH}$ .....	2.0 V min; 5.25 V max

## Output logic levels

Output high voltage, $V_{OH}$ sourcing 4 mA .....	2.4 V min; 3.465 V max
Output low voltage, $V_{OL}$ sinking 4 mA .....	0 V min; 0.4 V max

Minimum pulse width..... 20 ns

## Maximum frequencies for secondary digital functions

SPI .....	4 MHz
PWM.....	100 kHz
Quadrature encoder input .....	100 kHz
I <sup>2</sup> C .....	400 kHz

## UART lines

Maximum baud rate.....	230,400 bps
Data bits.....	5, 6, 7, 8
Stop bits .....	1, 2
Parity.....	Odd, Even, Mark, Space
Flow control.....	XON/XOFF

## Accelerometer

Number of axes.....	3
Range .....	$\pm 8$ g
Resolution .....	12 bits
Sample rate .....	800 S/s
Noise .....	3.9 mg <sub>rms</sub> typical at 25 °C

## Power Output

### +5 V power output

Output voltage .....	4.75 V to 5.25 V
Maximum current on each connector .....	100 mA

### +3.3 V power output

Output voltage .....	3.0 V to 3.6 V
Maximum current on each connector .....	150 mA

<b>+15 power output</b>	
Output voltage.....	+15 V to +16 V
Maximum current .....	32 mA (16 mA during startup)
<b>-15 V power output</b>	
Output voltage.....	-15 V to -16 V
Maximum current .....	32 mA (16 mA during startup)
Maximum combined power from +15 V and -15 V power output .....	
	500 mW

## Power Requirements

NI myRIO-1900 requires a power supply connected to the power connector.

Power supply voltage range.....	6 to 16 VDC
Maximum power consumption .....	14 W
Typical idle power consumption.....	2.6 W

## Environmental

To meet these specifications, you must operate the NI myRIO-1900 with the window facing away from the mounting surface and ensure that there is at least 1 in. of clearance in front of the window during use.

Ambient temperature near device (IEC 60068-2-1, IEC 600682-2).....	
	0 to 40 °C
Storage temperature (IEC 60068-2-1, IEC 600682-2).....	
	-20 to 70 °C
Operating humidity (IEC 60068-2-56) .....	10 to 90% RH, noncondensing
Storage humidity (IEC 60068-2-56) .....	10 to 90% RH, noncondensing
Maximum altitude.....	2,000 m
Pollution Degree (IEC 60664) .....	2

Indoor use only.

## Physical Characteristics

Weight.....	193 g (6.8 oz)
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## Safety

### Safety Standards

This product is designed to meet the requirements of the following standards of safety for electrical equipment for measurement, control, and laboratory use:

- IEC 61010-1, EN 61010-1
- UL 61010-1, CSA 61010-1





**Note** For UL and other safety certifications, refer to the product label or the [Online Product Certification](#) section.



**Caution** Using the NI myRIO-1900 in a manner not described in this document may impair the protection the NI myRIO-1900 provides.

## Hazardous Locations

The NI myRIO-1900 is not certified for use in hazardous locations.

## Electromagnetic Compatibility

This product meets the requirements of the following EMC standards for electrical equipment for measurement, control, and laboratory use:

- EN 61326-1 (IEC 61326-1): Class A emissions; Basic immunity
- EN 55022 (CISPR 22): Group 1, Class A emissions
- EN 55011 (CISPR 11): Group 1, Class A emissions
- AS/NZS CISPR 11: Group 1, Class A emissions
- AS/NZS CISPR 22: Group 1, Class A emissions
- FCC 47 CFR Part 15B: Class A emissions
- ICES-001: Class A emissions



**Note** For EMC declarations and certifications, refer to the [Online Product Certification](#) section.

## CE Compliance

This product meets the essential requirements of applicable European Directives as follows:

- 2006/95/EC; Low-Voltage Directive (safety)
- 2004/108/EC; Electromagnetic Compatibility Directive (EMC)
- 1999/5/EC; Radio and Telecommunications Terminal Equipment Directive (R&TTE)

## Online Product Certification

To obtain product certifications and the Declaration of Conformity (DoC) for this product, visit [ni.com/certification](http://ni.com/certification), search by model number or product line, and click the appropriate link in the Certification column.

## Environmental Management

NI is committed to designing and manufacturing products in an environmentally responsible manner. NI recognizes that eliminating certain hazardous substances from our products is beneficial to the environment and to NI customers.

For additional environmental information, refer to the *Minimize Our Environmental Impact* web page at [ni.com/environment](http://ni.com/environment). This page contains the environmental regulations and

directives with which NI complies, as well as other environmental information not included in this document.

## Waste Electrical and Electronic Equipment (WEEE)



**EU Customers** At the end of the product life cycle, all products *must* be sent to a WEEE recycling center. For more information about WEEE recycling centers, National Instruments WEEE initiatives, and compliance with WEEE Directive 2002/96/EC on Waste and Electronic Equipment, visit [ni.com/environment/weee](http://ni.com/environment/weee).

## 电子信息产品污染控制管理办法（中国 RoHS）



**中国客户** National Instruments 符合中国电子信息产品中限制使用某些有害物质指令 (RoHS)。关于 National Instruments 中国 RoHS 合规性信息, 请登录 [ni.com/environment/rohs\\_china](http://ni.com/environment/rohs_china)。(For information about China RoHS compliance, go to [ni.com/environment/rohs\\_china](http://ni.com/environment/rohs_china).)

## Regulatory Information

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### United States

#### FCC Radio Exposure

The radiated output power of this device is below the FCC radio frequency exposure limits. Nevertheless, this device should be used in such a manner that the potential for human contact during normal operation is minimized. This device has been evaluated for and shown compliant with the FCC RF Exposure limits under mobile exposure conditions (antennas are greater than 20 cm from a person's body). This device cannot be co-located with any other transmitter unless approved by FCC.

This product does not contain any user serviceable components. Any unauthorized product changes or modifications will invalidate the warranty and all applicable regulatory certifications and approvals.

#### FCC Interference Statement

This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the manufacturer's instruction manual, may cause interference with radio and television reception. This equipment has been tested and found to comply with the limits for a Class B digital device pursuant to Part 15 of the FCC Rules.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference.
2. This device must accept any interference received, including interference that may cause undesired operation.

This wireless adapter generates, uses, and can radiate radio frequency energy. If the wireless adapter is not installed and used in accordance with the instructions, the wireless adapter may

cause harmful interference to radio communications. There is no guarantee, however, that such interference will not occur in a particular installation. If this wireless adapter does cause harmful interference to radio or television reception (which can be determined by turning the equipment off and on), the user is encouraged to try to correct the interference by taking one or more of the following measures:

- Reorient or relocate the receiving antenna of the equipment experiencing the interference.
- Increase the distance between the wireless adapter and the equipment experiencing the interference.
- Connect the equipment to an outlet on a circuit different from which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

## Canada

### Industry Canada (IC) Notices

This product complies with Industry Canada RSS-210.

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Under Industry Canada regulations, the radio transmitter(s) in this device may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication.















### Avis d'Industry Canada (IC)



Cet appareil est conforme aux norme RSS210 d'Industrie Canada.

Cet appareil est conforme aux normes d'exemption de licence RSS d'Industry Canada. Son fonctionnement est soumis aux deux conditions suivantes : (1) cet appareil ne doit pas causer d'interférence et (2) cet appareil doit accepter toute interférence, notamment les interférences qui peuvent affecter son fonctionnement.

Conformément aux réglementations d'Industry Canada, les émetteurs radio de cet appareil ne peuvent fonctionner qu'à l'aide d'une antenne dont le type et le gain maximal (ou minimal) pour ces émetteurs – transmetteurs sont approuvés par Industry Canada. Pour réduire le risque d'interférence éventuelle pour les autres utilisateurs, le type et le gain de l'antenne doivent être choisis de manière à ce que la puissance isotrope rayonnée équivalente (p.i.r.e.) minimale nécessaire à une bonne communication soit fournie.

# EU Regulatory Statements

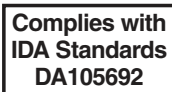
 Český [Czech]	<i>National Instruments</i> tímto prohlašuje, že tento NI myRIO-1900 je ve shodě se základními požadavky a dalšími příslušnými ustanoveními směrnice 1999/5/ES.
 Dansk [Danish]	Undertegnede <i>National Instruments</i> erklærer herved, at følgende udstyr NI cDAQ-1900 overholder de væsentlige krav og øvrige relevante krav i direktiv 1999/5/EF.
 Deutsch [German]	Hiermit erklärt <i>National Instruments</i> , dass sich das Gerät NI myRIO-1900 in Übereinstimmung mit den grundlegenden Anforderungen und den übrigen einschlägigen Bestimmungen der Richtlinie 1999/5/EG befindet.
 Eesti [Estonian]	Käesolevaga kinnitab <i>National Instruments</i> seadme NI myRIO-1900 vastavust direktiivi 1999/5/EÜ põhinõuetele ja nimetatud direktiivist tulenevatele teistele asjakohastele sätetele.
 English	Hereby, <i>National Instruments</i> , declares that this NI myRIO-1900 is in compliance with the essential requirements and other relevant provisions of Directive 1999/5/EC.
 Español [Spanish]	Por medio de la presente <i>National Instruments</i> declara que el NI myRIO-1900 cumple con los requisitos esenciales y cualesquiera otras disposiciones aplicables o exigibles de la Directiva 1999/5/CE.
 Ελληνική [Greek]	ΜΕ ΤΗΝ ΠΑΡΟΥΣΑ <i>National Instruments</i> ΔΗΛΩΝΕΙ ΟΤΙ NI myRIO-1900 ΣΥΜΜΟΡΦΩΝΕΤΑΙ ΠΡΟΣ ΤΙΣ ΟΥΣΙΩΔΕΙΣ ΑΠΑΙΤΗΣΕΙΣ ΚΑΙ ΤΙΣ ΛΟΙΠΕΣ ΣΧΕΤΙΚΕΣ ΔΙΑΤΑΞΕΙΣ ΤΗΣ ΟΔΗΓΙΑΣ 1999/5/EK.
 Français [French]	Par la présente <i>National Instruments</i> déclare que l'appareil NI myRIO-1900 est conforme aux exigences essentielles et aux autres dispositions pertinentes de la directive 1999/5/CE.
 Italiano [Italian]	Con la presente <i>National Instruments</i> dichiara che questo NI myRIO-1900 è conforme ai requisiti essenziali ed alle altre disposizioni pertinenti stabilite dalla direttiva 1999/5/CE.
 Latviski [Latvian]	Ar šo <i>National Instruments</i> deklarē, ka NI myRIO-1900 atbilst Direktīvas 1999/5/EK būtiskajām prasībām un citiem ar to saistītajiem noteikumiem.
 Lietuvių [Lithuanian]	Šiuo <i>National Instruments</i> deklaruoja, kad šis NI myRIO-1900 atitinka esminius reikalavimus ir kitas 1999/5/EB Direktyvos nuostatas.
 Nederlands [Dutch]	Hierbij verklaart <i>National Instruments</i> dat het toestel NI myRIO-1900 in overeenstemming is met de essentiële eisen en de andere relevante bepalingen van richtlijn 1999/5/EG.
 Malti [Maltese]	Hawnhekk, <i>National Instruments</i> , jiddikjara li dan NI myRIO-1900 jikkonforma mal-htigijiet essenzjali u ma provvedimenti oħrajn relevanti li hemm fid-Dirrettiva 1999/5/EC.
 Magyar [Hungarian]	Alulírott, <i>National Instruments</i> nyilatkozom, hogy a NI myRIO-1900 megfelel a vonatkozó alapvető követelményeknek és az 1999/5/EC irányelv egyéb előírásainak.

 Polski [Polish]	Niniejszym <i>National Instruments</i> . oświadcza, że NI myRIO-1900 jest zgodny z zasadniczymi wymogami oraz pozostałymi stosownymi postanowieniami Dyrektywy 1999/5/EC.
 Português [Portuguese]	<i>National Instruments</i> declara que este NI myRIO-1900 está conforme com os requisitos essenciais e outras disposições da Directiva 1999/5/CE.
 Slovensko [Slovenian]	<i>National Instruments</i> izjavlja, da je ta NI myRIO-1900 v skladu z bistvenimi zahtevami in ostalimi relevantnimi določili direktive 1999/5/ES.
 Slovenský [Slovak]	<i>National Instruments</i> týmto vyhlasuje, že NI myRIO-1900 spĺňa základné požiadavky a všetky príslušné ustanovenia Smernice 1999/5/ES.
 Suomi [Finnish]	<i>National Instruments</i> vakuuttaa täten että NI myRIO-1900 tyyppinen laite on direktiivin 1999/5/EY oleellisten vaatimusten ja sitä koskevien direktiivin muiden ehtojen mukainen.
 Svenska [Swedish]	Härmed intygar <i>National Instruments</i> att denna NI myRIO-1900 står i överensstämmelse med de väsentliga egenskapskrav och övriga relevanta bestämmelser som framgår av direktiv 1999/5/EG.
Íslenska [Icelandic]	Hér með lýsir <i>National Instruments</i> yfir því að NI myRIO-1900 er í samræmi við grunnkröfur og aðrar kröfur, sem gerðar eru í tilskipun 1999/5/EC.
 Norsk [Norwegian]	<i>National Instruments</i> erklærer herved at utstyret NI myRIO-1900 er i samsvar med de grunnleggende krav og øvrige relevante krav i direktiv 1999/5/EF.



**Note** Refer to the Declaration of Conformity (DoC) for this product for any additional regulatory compliance information. To obtain the DoC for this product, visit [ni.com/certification](http://ni.com/certification), search by model number or product line, and click the appropriate link in the Certification column.

## Singapore



## Taiwan R.O.C.

### 低功率電波輻射性電機管理辦法

第十二條經型式認證合格之低功率射頻電機，非經許可，公司、商號或使用者均不得擅自變更頻率、加大功率或變更原設計之特性及功能。

第十四條低功率射頻電機之使用不得影響飛航安全及干擾合法通信；經發現有干擾現象時，應立即停用，並改善至無干擾時方得繼續使用。

前項合法通信，指依電信規定作業之無線電信。低功率射頻電機須忍受合法通信或工業、科學及醫療用電波輻射性電機設備之干擾。

## Mexico

La operación de este equipo está sujeta a las siguientes dos condiciones:

- 1) es posible que este equipo o dispositivo no cause interferencia perjudicial y
- 2) este equipo debe aceptar cualquier interferencia, incluyendo la que pueda causar su propia operación no deseada.

## Brazil



## Brasil-Aviso da Anatel

Este equipamento opera em caráter secundário, isto é, não tem direito a proteção contra interferência prejudicial, mesmo de estações do mesmo tipo, e não pode causar interferência a sistemas operando em caráter primário.

## Warranty

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For customers other than private individual users in the EU: The NI myRIO-1900 is warranted against defects in materials and workmanship for a period of one year from the date of shipment, as evidenced by receipts or other documentation. National Instruments will, at its option, repair or replace equipment that proves to be defective during the warranty period. This warranty includes parts and labor.

For private individual users in the EU: Based on your statutory rights, National Instruments will—through its distributor—cure defects in materials and workmanship within two years from delivery.

## Worldwide Support and Services

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The NI website is your complete resource for technical support. At [ni.com/support](https://ni.com/support) you have access to everything from troubleshooting and application development self-help resources to email and phone assistance from NI Application Engineers.

Visit [ni.com/services](https://ni.com/services) for NI Factory Installation Services, repairs, extended warranty, and other services.

Visit [ni.com/register](https://ni.com/register) to register your NI product. Product registration facilitates technical support and ensures that you receive important information updates from NI.

A Declaration of Conformity (DoC) is our claim of compliance with the Council of the European Communities using the manufacturer's declaration of conformity. This system affords the user protection for electromagnetic compatibility (EMC) and product safety. You can obtain the DoC for your product by visiting [ni.com/certification](https://ni.com/certification). If your product supports calibration, you can obtain the calibration certificate for your product at [ni.com/calibration](https://ni.com/calibration).

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**Manufacturer:** National Instruments

**Board Assembly Part Numbers** (Refer to Procedure 1 for identification procedure):

Part Number and Revision	Description
154062A-05L or later	USRP N200, Shipping Kit P/N 782746-01
154062A-04L or later	USRP N210, Shipping Kit P/N 782747-01
724793-01	FIREFLY-1A GPSDO (Optional), Shipping Kit P/N 782779-01

### Volatile Memory

<i>Target Data</i>	<i>Type</i>	<i>Size</i>	<i>Battery Backup</i>	<i>User<sup>1</sup> Accessible</i>	<i>System Accessible</i>	<i>Sanitization Procedure</i>
Distributed data storage	FPGA LUTRAM	47 KB	No	Yes	Yes	Cycle Power
Data storage during VI execution	FPGA Block RAM	284 KB	No	Yes	Yes	Cycle Power
External data storage	SRAM	1152 KB	No	Yes	Yes	Cycle Power

### Non-Volatile Memory (*incl. Media Storage*)

<i>Target Data</i>	<i>Type</i>	<i>Size</i>	<i>Battery Backup</i>	<i>User Accessible</i>	<i>System Accessible</i>	<i>Sanitization Procedure</i>
FPGA Configuration	FLASH	4 MB	No			
<ul style="list-style-type: none"> <li>• FPGA Image</li> <li>• Configuration Data</li> </ul>				No	Yes	None
Motherboard Configuration Data	EEPROM	256 B	No	No	Yes	None
GPS Parameters EEPROM (optional)	EEPROM	2 KB	No	No	Yes	None
GPS Executable Program Memory (optional)	FLASH	512 KB	No	No	Yes	None

<sup>1</sup> Refer to *Terms and Definitions* section for clarification of *User* and *System Accessible*

## Procedures

### **Procedure 1 –Board Assembly Part Number Identification:**

To determine the Board Assembly Part Number and Revision, refer to the label applied to the surface of your product. The Assembly Part Number should be formatted as “P/N: 154062x-#L” where “x” is the letter module revision and “#” determines whether the module is a USRP-2920, USRP-2921, or USRP-2922 (refer to the Board Assembly Part Numbers table).

## Terms and Definitions

### **Cycle Power:**

The process of completely removing power from the device and its components and allowing for adequate discharge. This process includes a complete shutdown of the PC and/or chassis containing the device; a reboot is not sufficient for the completion of this process.

### **Volatile Memory:**

Requires power to maintain the stored information. When power is removed from this memory, its contents are lost. This type of memory typically contains application specific data such as capture waveforms.

### **Non-Volatile Memory:**

Power is not required to maintain the stored information. Device retains its contents when power is removed. This type of memory typically contains information necessary to boot, configure, or calibrate the product or may include device power up states.

### **User Accessible:**

The component is read and/or write addressable such that a user can store arbitrary information to the component from the host using a publicly distributed NI tool, such as a Driver API, the System Configuration API, or MAX.

### **System Accessible:**

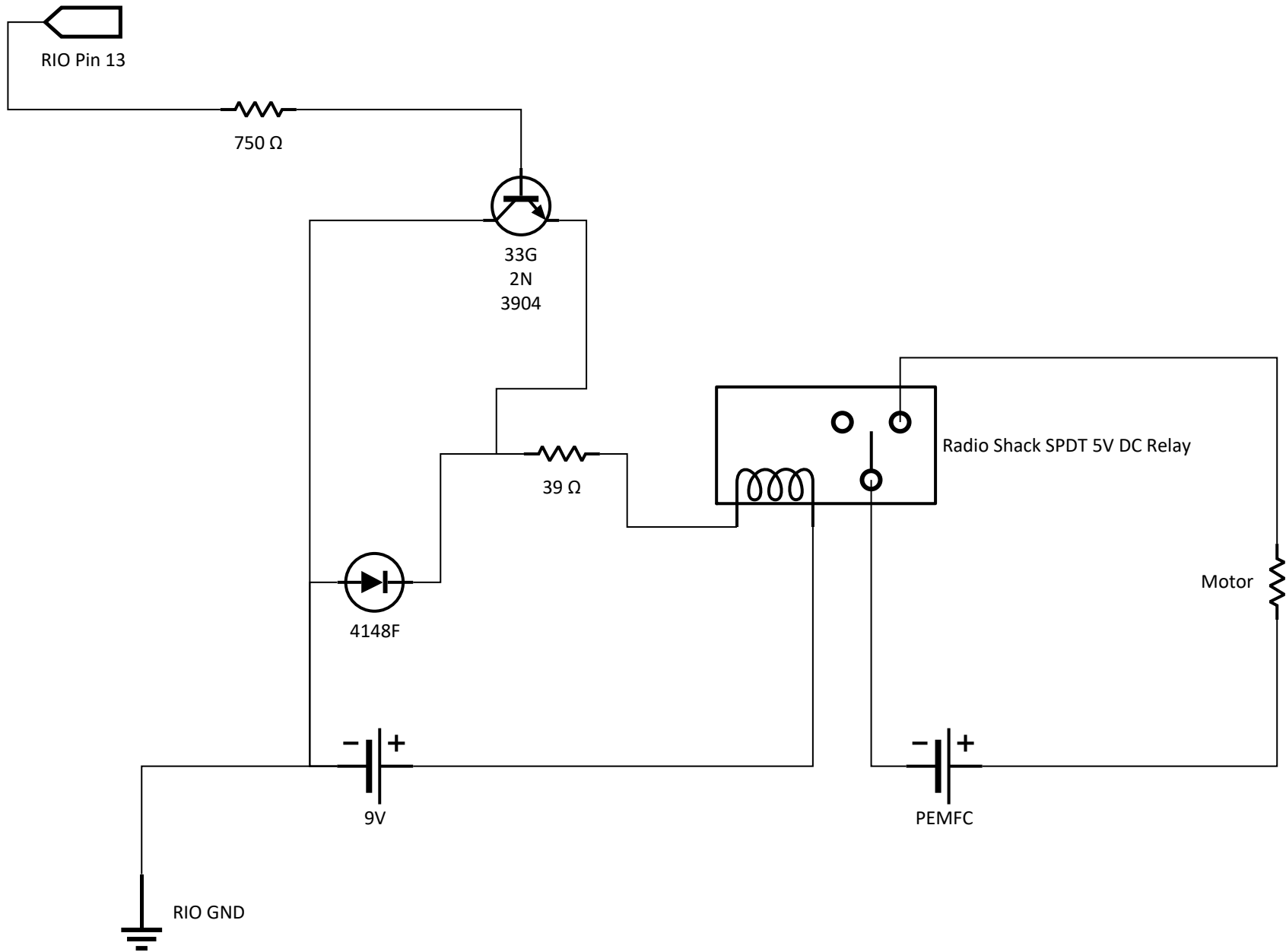
The component is read and/or write addressable from the host without the need to physically alter the product.

### **Clearing:**

Per *NIST Special Publication 800-88 Revision 1*, “clearing” is a logical technique to sanitize data in all User Accessible storage locations for protection against simple non-invasive data recovery techniques using the same interface available to the user; typically applied through the standard read and write commands to the storage device.

### **Sanitization:**

Per *NIST Special Publication 800-88 Revision 1*, “sanitization” is a process to render access to “Target Data” on the media infeasible for a given level of effort. In this document, clearing is the degree of sanitization described.







# 275-0240 Radio Shack 5-volt relay

Revision as of 17:56, 24 February 2006 by [Woozle](#) ([talk](#) | [contribs](#)) (image of actual unit) ([diff](#)) ← [Older revision](#) | [Latest revision](#) ([diff](#)) | [Newer revision](#) → ([diff](#))

## Coil voltage

Nominal: 5VDC  
Maximum: 6.5VDC

## Nominal current:

89.3mA

## Pick-up voltage:

3.5VDC

## Drop-out voltage:

0.25VDC

## Coil resistance:

56 ohms  $\pm$ 10%

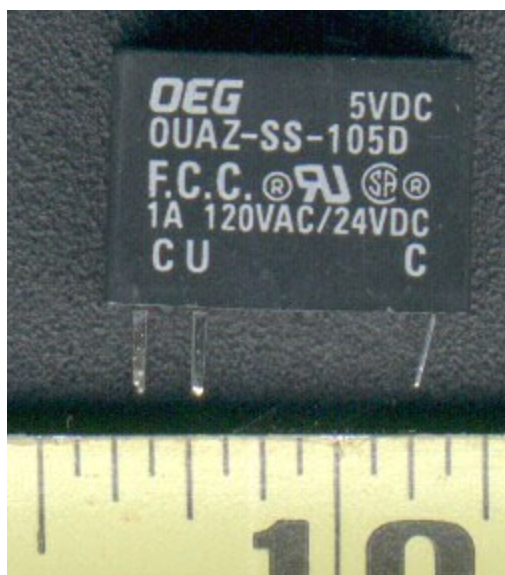
## Life

Electrical (at rated voltage and current): 100,000 cycles

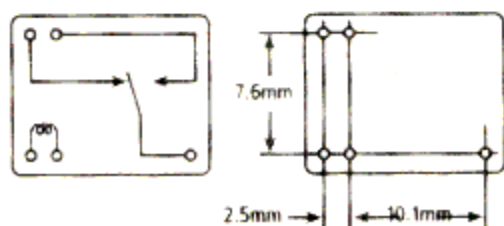
Mechanical (with no load): 10,000,000 cycles

## Operating temperature:

-22° to 167°F  
(-30°C to 75°C)  
at 20-80% RH



## Bottom View



Retrieved from "[https://htyp.org/mw/index.php?title=275-0240\\_Radio\\_Shack\\_5-volt\\_relay&oldid=3383](https://htyp.org/mw/index.php?title=275-0240_Radio_Shack_5-volt_relay&oldid=3383)"

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## SHIELDED 9 VOLT BATTERY STRAPS

- Insulates and shields 9 Volt battery snap-on connector contacts
- Assures safe secure use, reduces the potential of short circuits and prevents tampering with battery contacts
- Protects circuits, prevents unwanted electrical discharge due to unintended grounding
- Protects battery contacts from dust, dirt, and physical damage
- Ideal for rugged applications, made of high impact molded plastic with integral wire lead strain relief

Modifications available with different wire lengths.

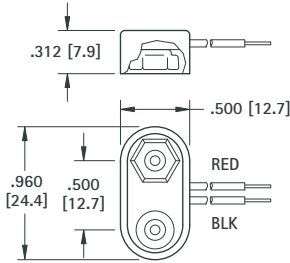
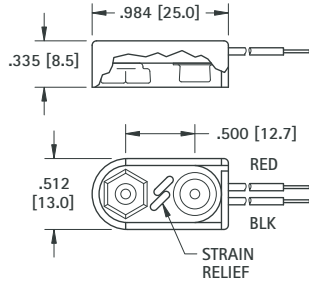
### SPECIFICATIONS

Base: ABS

Male/Female Contacts: Brass, Nickel Plate

Wires (Red & Black): #26 AWG, Tinned, .187 (4.8) end strip, UL/CSA1007

\*Tolerance on lead length +/- .250 (6.4)



I STYLE		T STYLE	
MOLDED		MOLDED	
CAT. NO.	*LEAD LENGTH	CAT. NO.	*LEAD LENGTH
84-4	4.00 (101.6)	81-4	4.00 (101.6)
84-6	6.00 (152.4)	81-6	6.00 (152.4)
84-8	8.00 (203.2)	81-8	8.00 (203.2)

## PREMIUM 9 VOLT BATTERY STRAPS

- Fully Assembled
- Rigid Assembly
- Ideal for rugged applications, made of high impact molded plastic with integral wire lead strain relief

Rigidly constructed. Nickel plate, male and female contacts. Female contacts are spring temper. Accepts numerous insertions to meet U.L. approved standards. Provides excellent mechanical strength and low contact resistance. Wires have tinned copper conductors, PVC insulation and the ends are stripped for easy connection.

Wires are rated to +176°F (+80°C) and 300V and meet UL/CSA #1061/#1007 requirements.

Modifications available with different wire lengths.

### SPECIFICATIONS

Contacts: Phosphor Bronze, Nickel Plate

Wire: #26 AWG, 7/34

End Strip: .250 (6.4) Long, Tinned

Base: Polypropylene

\*Tolerance on lead length +/- .250 (6.4)



Base Size:  
1.062 (27.0) x .512 (13.0)

I STYLE		T STYLE	
MOLDED		MOLDED	
CAT. NO.	*LEAD LENGTH	CAT. NO.	*LEAD LENGTH
2238	4.00 (101.6)	2241	4.00 (101.6)
2239	6.00 (152.4)	2242	6.00 (152.4)
2240	8.00 (203.2)	2243	8.00 (203.2)



Base Size:  
1.00 (25.4) x .512 (13.0)

## ECONOMY 9 VOLT BATTERY STRAPS

- Fully Assembled
- Rigid Assembly

When product cost is of the utmost importance these economy battery straps will suit your needs. Brass contacts, nickel plated with vinyl or ABS covering. Wires have tinned copper conductors, PVC insulation and the ends are stripped for easy connection. Wires meet UL/CSA #1007 requirements.

Modifications available with different wire lengths

### SPECIFICATIONS

Contacts: Brass, Nickel Plate

Wire: #26 AWG, 7/34

End Strip: .250 (6.4) Long, Tinned

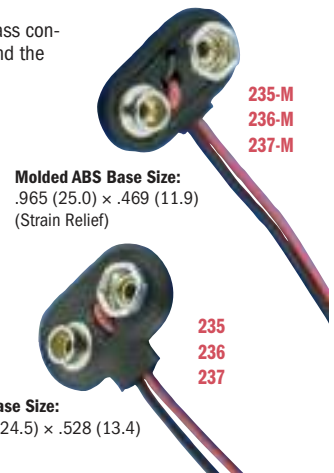
\*Tolerance on lead length +/- .250 (6.4)



Molded ABS Base Size:  
.984 (25.0) x .469 (11.9)  
(Strain Relief)

Vinyl Base Size:  
1.125 (31.8) x .530 (13.5)

I STYLE			T STYLE		
MOLDED VINYL		*LEAD LENGTH	MOLDED VINYL		CAT. NO.
CAT. NO.	CAT. NO.		CAT. NO.	CAT. NO.	
232-M	232	4.00 (101.6)	235-M	235	
233-M	233	6.00 (152.4)	236-M	236	
234-M	234	8.00 (203.2)	237-M	237	



Molded ABS Base Size:  
.965 (25.0) x .469 (11.9)  
(Strain Relief)

Vinyl Base Size:  
1.000 (24.5) x .528 (13.4)

# TRUSTED POWER BY DURACELL®



TRUST THE RELIABLE POWER CHOICE  
FOR PROFESSIONALS  
WITH DURACELL® PROCELL® BATTERIES



5LE23



5LE25



5LE22



5LE21



5LE24

## DURACELL® PROCELL® ALKALINE BATTERIES

THE EFFICIENT POWER CHOICE

- + Increased battery life = longer service life, less man hours replacing the batteries, lowered operating costs, and operational improvement.
- + Less maintenance = less downtime in your facility, increasing efficiency throughout your location.
- + Procell batteries are engineered for intermittent use, so the battery is not expelling energy when the device is off, providing longer life and increased productivity.
- + Procell batteries are economically packaged for professional applications.
- + Procell batteries have a 7 year shelf life (each battery is individually date coded to ensure freshness).
- + Contains no added mercury.
- + Reliable operation in temperatures between -4°F to 129°F.
- + Procell batteries can be used for increasing productivity, emergency preparedness, inventory management (Keepstock), and safety devices.

Duracell Part #	Size	Qty./Pk.	Grainger Part #
PC1500BKD	AA	24	5LE23
PC2400BKD	AAA	24	5LE25
PC1400	C	12	5LE22
PC1300	D	12	5LE21
PC1604BKD	9V	12	5LE24

DURACELL + PROFESSIONAL

For more information contact your Grainger Representative or visit [Grainger.com](http://Grainger.com)®.

AVAILABLE THROUGH

**GRAINGER**  
FOR THE ONES WHO GET IT DONE


 Close this window

SDS

**Common Name:** EXEMPT

**Manufacturer:** N/A

**SDS Revision Date:** (No Date)

**SDS Format:** No Format Specified

**Item Number(s):** 13J015, 13J016, 13J017, 14N211, 14N212, 14N213, 19N836, 19N837, 19N838, 19N839, 19N840, 19N841, 19N842, 1JU96, 1PCK4, 2TUU4, 32PD27, 32PD28, 32UT26, 32WK44, 32WK45, 32WK46, 32WK47, 32WK48, 32WK49, 32WK50, 32WK51, 32WK52, 32WK53, 32WK54, 32WK55, 32WK56, 32WK57, 32WK58, 32WK59, 32WK60, 32WK61, 32WK62, 32WK63, 32WK64, 32WK65, 32WK66, 32WK67, 32WK68, 32WK69, 32WK70, 32WK71, 32WK72, 32WK73, 32WK74, 32WK75, 32WK76, 32WK77, 32WK78, 32WK79, 32WK80, 32WK81, 32WK82, 32WK83, 32WK84, 32WK85, 32WK86, 32WK87, 32WK88, 32WK89, 32WK90, 32WK91, 32WK92, 32WK93, 32WK94, 32WK95, 32WK96, 32WK97, 32WK98, 32WK99, 32WL01, 32WL02, 32WL03, 32WL04, 32WL05, 32WL06, 32WL07, 32WL08, 32WL09, 32WL10, 32WL11, 32WL12, 32WL13, 32WL14, 32WL15, 32WL16, 32WL17, 32WL18, 32WL19, 32WL20, 32WL21, 32WL22, 32WL23, 32WL24, 32WL25, 32WL26, 32WL27, 32WL28, 32WL29, 32WL30, 32WL31, 32WL32, 32WL33, 32WL34, 32XV54, 32XV55, 32XV56, 33GP19, 33GP21, 33GP22, 33GP24, 33GP27, 33GP28, 33GP30, 33GP31, 33GP33, 33GP35, 33GP36, 33GP38, 33GP39, 33GP41, 33GP45, 33GP46, 33GP48, 33GP51, 33GP52, 33GP53, 33GP54, 33GP56, 33GP57, 33GP59, 33GP65, 33GP67, 33GP68, 33GP70, 33GP72, 33GP73, 33GP75, 33GP77, 33GP78, 33GP82, 33GP83, 33GP91, 33GP93, 33GP95, 33GP96, 33GP97, 33GR04, 33GR06, 33GR07, 33GR09, 33GR11, 33GR15, 33GR16, 33GR17, 33GR21, 33GR29, 33GR30, 33GR31, 33GR34, 33GR37, 33GR51, 33GR52, 33GR57, 33GR60, 33GR63, 33GR64, 33GR65, 33GR68, 33GR71, 33GR72, 33GR76, 33GR80, 33GR86, 33GR89, 33GR96, 33GR99, 33GT02, 33HE76, 33HE79, 33HE80, 33KJ92, 33M143, 33NT84, 33TU67, 33TU68, 33TU69, 33TU70, 33TU71, 33TU72, 33TU73, 33TU74, 33V970, 33V972, 33V975, 33X336, 33X679, 33X680, 33X682, 33X683, 33X684, 34NK15, 34NK16, 34NK29, 34NK30, 34NK31, 34NK32, 34NK33, 34NK34, 34NK35, 34NK36, 34NK37, 34NK38, 34NK39, 34NK40, 34TJ38, 35HW59, 35LP49, 35LP50, 35LP51, 35LP52, 35V586, 35Z912, 35Z913, 35Z914, 36E896, 36L585, 36N564, 36N565, 36P399, 38G268, 38M486, 38V847, 39C313, 39C314, 39C331, 39C332, 39C333, 39C343, 39C415, 39E508, 39E509, 39E510, 39E682, 39E683, 39E684, 39E691, 39E701, 39E703, 39N930, 39P315, 39P316, 3AC22, 3AC23, 3ARD6, 3ARD7, 3ARD8, 3ARE1, 3ARE2, 3AZZ1, 3AZZ2, 3AZZ3, 3AZZ4, 3AZZ5, 3AZZ6, 3AZZ7, 3AZZ8, 3BE37, 3BE38, 3BE39, 3BE43, 3BE44, 3BE45, 3BE46, 3BU56, 3CE47, 3CE48, 3CNZ3, 3DPW4, 3DPW5, 3DPW7, 3DPW9, 3DPX1, 3DPX4, 3EAV7, 3EAX4, 3ELP2, 3ELP3, 3ELP4, 3FMJ5, 3FMJ6, 3FMJ7, 3FMJ8, 3FMJ9, 3FMK1, 3FMK2, 3FMK3, 3FMK4, 3FMK5, 3FMK6, 3FMK7, 3FMK8, 3FMK9, 3FML1, 3FML2, 3FML3, 3FML4, 3FML5, 3FML6, 3FML7, 3FML8, 3FML9, 3FMN1, 3FMN2, 3FMN3, 3FMN4, 3FMN5, 3FMN6, 3FMN7, 3FMN8, 3FMN9, 3FMP1, 3FMP2, 3FMP3, 3FMP4, 3FMP5, 3FMP6, 3FMP7, 3FMP8, 3FMP9, 3FMR1, 3FMR2, 3FMR3, 3FMR4, 3FMR5, 3FMR6, 3FMR7, 3FMR8, 3FMR9, 3FMT1, 3FMT2, 3FMT3, 3FMT4, 3FMT5, 3FMT6, 3FMT7, 3FMT8, 3FMT9, 3FMU1, 3FMU2, 3FMU3, 3FMU4, 3FMX7, 3FMX8, 3FRN1, 3FRN2, 3FRN3, 3FRN4, 3FRN5, 3FRN6, 3FRP1, 3FRP2, 3FRP3, 3FRP4, 3FRP6, 3FRP7, 3FRP8, 3FRP9, 3FRR3, 3FRR4, 3FRR5, 3FRR6, 3FU83, 3FY86, 3FY87, 3HAH4, 3HAH5, 3HAH6, 3HB20, 3HB21, 3HB22, 3HB27, 3HB28, 3HB29, 3HB42, 3HB43, 3HB44, 3HB45, 3HB46, 3HB47, 3HB48, 3HB49, 3HB50, 3HB51, 3HB52, 3HB53, 3HB54, 3HB55, 3HB56, 3HB57, 3HUR5, 3JEX2, 3JFG6, 3JLR4, 3JLR5, 3JLR6, 3JLR7, 3JME5, 3JMF3, 3JML5, 3JMY2, 3JMY3, 3JMY4, 3JMY5, 3JMY6, 3JMY7, 3JMY8, 3JMY9, 3JNA5, 3JNJ2, 3JNL1, 3JNL4, 3JNL5, 3JNX3, 3JT31, 3JT33, 3JW39, 3JW40, 3JW41, 3JW42, 3JW43, 3JW44, 3JW46, 3KA71, 3KR68, 3KR69, 3KR71, 3KRU2, 3KRU3, 3KRU4, 3KRU5, 3KRU6, 3KRU7, 3KRU8, 3KRU9, 3KZJ4, 3KZJ6, 3L877, 3L879, 3LA52, 3LDH4, 3LE86, 3LHW9, 3LKF9, 3LKK1, 3LKK2, 3LPX6, 3LPX8, 3LPY1, 3LPY3, 3LPY5, 3LPY7, 3LPY9, 3LPZ2, 3LPZ4, 3LPZ6, 3LPZ8, 3LRA1, 3LRA7, 3LRA9, 3LRC2, 3LRE8, 3LRF1, 3LRF3, 3LRF5, 3LRF7, 3LY80, 3LY82, 3LY86, 3LY88, 3MNC7, 3MNC9, 3MND2, 3MND4, 3MND6, 3MNF4, 3MNF6, 3MNF8, 3MNN4, 3MNL3, 3MNL7, 3MU69, 3MUD1, 3MUD2, 3MY51, 3MY52, 3NE72, 3NE73, 3NE74, 3NE75, 3NE76, 3NLJ9, 3NLK1, 3NLX6, 3NLX7, 3NMG7, 3NNE5, 3NNG7, 3NNG8, 3NNK6, 3NNK7, 3NNK9, 3NNL5, 3NNL7, 3NRA3, 3NRA4, 3NRA5, 3NRA6, 3NRA7, 3NRA8, 3NRA9, 3NRC1, 3NRH7, 3NRH8, 3NRJ2, 3NRJ5, 3NRN4, 3PB39, 3PB40, 3PB41, 3PDK9, 3PDL2, 3PDL4, 3PET6, 3PET8, 3PET9, 3PPN5, 3PPN6, 3PVJ1, 3PVT3, 3PVT4, 3PVU3, 3PVU4, 3PVU5, 3RPC5, 3RPC6, 3RPL4, 3RPL5, 3RPN1, 3RPN2, 3RPN4, 3RPN5, 3RPN7, 3RPP8, 3RPP9, 3RPR1, 3RPR8, 3RTU6, 3RTZ5, 3RUR8, 3TAT4, 3TAT6, 3TAT7, 3TAT8, 3TAT9, 3TAU2, 3TAU4, 3TAU5, 3THE2, 3THE3, 3THE4, 3THE5, 3THE6, 3THE7, 3THE8, 3THE9, 3THF1, 3THF2, 3THF3, 3THF4, 3THF5, 3THF7, 3THF8, 3THF9, 3TP52, 3TP53, 3TPT7, 3TPT8, 3TPU1, 3TPU2, 3TPU3, 3TRD6, 3TRE6, 3TRE9, 3TRH6, 3TRJ3, 3TRJ6, 3TRV7, 3TYG4, 3TYG5, 3TYH6, 3TYK2, 3TYN3, 3TYN4, 3U560, 3U905, 3UCH3, 3UEE2, 3UEE5, 3UEG5, 3UFV5, 3UNV4, 3UUG9, 3UVC9, 3UVY1, 3UVY5, 3UVZ1, 3UWA3, 3VAN3, 3VAN4, 3VCZ7, 3VXH7, 3VYZ8, 3VZN8, 3VZP7, 3WA88, 3WA89, 3WA91, 3WA92, 3WAJ4, 3WAJ9, 3WAK1, 3WAK6, 3WAL1, 3WB48, 3WEW3, 3WEW8, 3WEZ5, 3WMP6, 3WMP7, 3WMP8, 3WMX6, 3WND7, 3WND8, 3WNF9, 3WNG1, 3WRC8, 3WU64, 3WU65, 3WUZZ, 3WZC1, 3X673, 3X676, 3X677, 3XKW4, 3XKW6, 3XRY4, 3YAG3, 3YEC1, 3YEC4, 3YNC1, 3YRX6, 3YRX9, 3YRY6, 3YTH7, 3YWC4,

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**Manufacturer Model Number(s):**

A SAFETY DATA SHEET (SDS) IS NOT REQUIRED FOR THIS ITEM BECAUSE THE PRODUCT HAS BEEN DETERMINED EXEMPT FROM THE UPDATED HAZARD COMMUNICATION STANDARD (29 CFR 1910.1200) BY THE PRODUCT MANUFACTURER.

### **Lead Source Shipping Tube & Aluminum Shield**

Lead tubes such as the one used in the ChemE Car that Cud are used as packaging for radiation sources used in radiation therapy, and as such have no documentation of their own. Aluminum shields are similarly used for shielding. Our materials was donated by Todd Christensen of Pole Mountain Medical Physics ([medrad@wyoming.usa.com](mailto:medrad@wyoming.usa.com)).

## **Canvas**

No manufacturer's specifications available.



**Corning Incorporated  
Life Sciences**

**Registered  
ISO 9001:2008**

## Product Description

**Catalog Number:** 1060-200

**Product Description:** PYREX® Beaker, Berzelius, Tall Form, with Spout, Single Scale, 200 mL

**Component Materials:**

Type I Class A - Low-Expansion Borosilicate Glass, per ASTM E438 (Standard Specification for Glasses in Laboratory Apparatus)

**Attributes:**

ASTM Reference - E960 Specification for Laboratory Glass Beakers  
Capacity - 200 mL ±10 mL at any mark (5% of full capacity)  
Product Dimensions - 56 mm Body OD x 102 mm High

**Autoclaving:**

This product will withstand repeated standard autoclave cycles of 121°C at 15 psi for 15 minutes.

**Heating / Cooling:**

This product is designed for heating by hot plate, flame, oven, microwave or heating mantles. In normal service it can be heated many times to 230°C. It can be heated one time to 490°C in extreme service.

This product can be cooled to -230°C. DO NOT plunge product directly into a liquid coolant. Place the product in the vapor phase of the liquified gasses for slow cooling prior to immersion in the coolant.

**Vacuum / Pressure:**

This product is not designed for and is not rated for vacuum or pressure applications.

**Sterilization:**

Shipped Not Sterile

**TSE/BSE:**

Materials of animal origin are not used in the manufacture of this product.

**Lot Number Designation:**

Each production lot is uniquely identified with an 8 digit lot number as follows: First 3 digits - Julian date, start of manufacturing; Next 2 digits - Year of manufacture; Last 3 digits - Batch identification.

**Revision Date:**

06 MAR 2013

Rev No: 1

# Material Safety Data Sheet

Material Name : Glass Code 7740

ID: C-021

## \*\*\* Section 1 - Chemical Product and Company Identification \*\*\*

**Chemical Name:** NA

**Product Use:** Use in manufacture of glass articles

**Synonyms:** GC-7740

### Manufacturer Information

Corning Incorporated

Phone: (607) 974-7661

HP-ME-02-48

Corning, NY 14831

Emergency # CHEMTREC: (800) 424-9300

## \*\*\* Section 2 - Composition / Information on Ingredients \*\*\*

CAS #	Component	Percent
65997-17-3	Glass, oxide, chemicals	100

### Component Related Regulatory Information

This product may be regulated, have exposure limits or other information identified as the following: Nuisance particulates.

### Component Information/Information on Non-Hazardous Components

Glass is a solid material produced by combining various raw materials (e.g. oxides, carbonates, etc.), melting these components together, and cooling to a non-crystalline solid having its own unique properties.

Processing of this article may produce dusts or fumes which are considered hazardous under 29 CFR 1910.1200 (Hazard Communication).

## \*\*\* Section 3 - Hazards Identification \*\*\*

### Emergency Overview

This is a non-combustible, non-reactive solid material. It is supplied in the form of glass sheets or powder. Use methods suitable to fight surrounding fire. Exposure to glass powder or dusts may be irritating to eyes, nose, and throat. At very high exposure levels the dust may have an effect on the lungs.

### Hazard Statements

Dust or powder may be irritating to the eyes, skin, respiratory system and gastrointestinal tract.

### Potential Health Effects: Eyes

Dust or powder may irritate eye tissue. Symptoms can include irritation, redness, scratching of the cornea, and tearing.

Rubbing may cause abrasion of cornea.

### Potential Health Effects: Skin

No components in this product are known to be absorbed through the skin. Dust or powder may irritate the skin. Mechanical rubbing may increase skin irritation.

### Potential Health Effects: Ingestion

May cause temporary irritation of the throat, stomach, and gastrointestinal tract.

### Potential Health Effects: Inhalation

Dusts of this product may cause irritation of the nose, throat, and respiratory tract. When inhaled in very large amounts, damage to the lung can occur.

**HMIS Ratings: Health: 0 Fire: 0 Reactivity: 0 Pers. Prot.:** gloves/glasses

Hazard Scale: 0 = Minimal 1 = Slight 2 = Moderate 3 = Serious 4 = Severe \* = Chronic hazard

## \*\*\* Section 4 - First Aid Measures \*\*\*

### First Aid: Eyes

Eye injuries from glass particles should be treated by a physician immediately.

### First Aid: Skin

Cuts or abrasions should be treated promptly with thorough cleansing of the affected area.

### First Aid: Ingestion

Seek medical attention if material is ingested.

### First Aid: Inhalation

Move person to non-contaminated air. Call a physician if symptoms persist.

# Material Safety Data Sheet

Material Name : Glass Code 7740

ID: C-021

## First Aid: Notes to Physician

None.

### \*\*\* Section 5 - Fire Fighting Measures \*\*\*

**Flash Point:** Not applicable

**Method Used:** Not applicable

**Upper Flammable Limit (UFL):** Not applicable

**Lower Flammable Limit (LFL):** Not applicable

**Auto Ignition:** Not applicable

**Flammability Classification:** Will not burn

**Rate of Burning:** Not applicable

## General Fire Hazards

This material will not burn.

## Hazardous Combustion Products

Material will begin softening at about 700° C, will proceed to a liquid and will form irritating and toxic gaseous metallic oxides at extremely high temperatures.

## Extinguishing Media

Use methods for the surrounding fire.

## Fire Fighting Equipment/Instructions

Wear full protective clothing, including helmet, self-contained positive pressure or pressure demand breathing apparatus, protective clothing and face mask.

**NFPA Ratings: Health: 0 Fire: 0 Reactivity: 0**

Hazard Scale: 0 = Minimal 1 = Slight 2 = Moderate 3 = Serious 4 = Severe

### \*\*\* Section 6 - Accidental Release Measures \*\*\*

## Containment Procedures

Avoid creating dusts.

## Clean-Up Procedures

Wear appropriate protective equipment and clothing during clean-up. Collect spill using a vacuum cleaner with a HEPA filter. Place in a closed container.

## Evacuation Procedures

None necessary.

## Special Procedures

Regulations vary. Consult local authorities before disposal. Glass products may be recycled.

### \*\*\* Section 7 - Handling and Storage \*\*\*

## Handling Procedures

Do not inhale dusts. Avoid generation of airborne dusts. Avoid contact with skin and eyes. Wash thoroughly after handling.

## Storage Procedures

Store in a dry area.

### \*\*\* Section 8 - Exposure Controls / Personal Protection \*\*\*

## Exposure Guidelines

### A: General Product Information

The OSHA air contaminants exposure limits (PELs) are those provided in the 1989 update to 29 CFR 1910.1000. These limits were vacated by OSHA and may not be enforceable. Observe an exposure limit of 15 mg/m<sup>3</sup> (total dust) and 5 mg/m<sup>3</sup> (respirable fraction) for particulate not otherwise classified (PNOCs).

# Material Safety Data Sheet

Material Name : Glass Code 7740

ID: C-021

## B: Component Exposure Limits

### Glass, oxide, chemicals (65997-17-3)

- ACGIH: 10 mg/m<sup>3</sup> TWA (inhalable fraction, particulate matter containing no asbestos and <1% crystalline silica); 3 mg/m<sup>3</sup> TWA (respirable fraction, particulate matter containing no asbestos and <1% crystalline silica) (related to Particulates not otherwise specified (PNOS))
- OSHA (Final): 15 mg/m<sup>3</sup> TWA (total dust); 5 mg/m<sup>3</sup> TWA (respirable fraction) (related to Particulates not otherwise regulated)
- OSHA (Vacated): 15 mg/m<sup>3</sup> TWA (total dust); 5 mg/m<sup>3</sup> TWA (respirable fraction) (related to Particulates not otherwise regulated)

## Engineering Controls

If material is ground, cut, or used in any operation which may generate dusts, use appropriate local exhaust ventilation to keep exposures below the recommended exposure limits.

## PERSONAL PROTECTIVE EQUIPMENT

### Personal Protective Equipment: Eyes/Face

Wear safety glasses with side shields.

### Personal Protective Equipment: Skin

Wear leather or other appropriate work gloves, if necessary for type of operation. The use of coveralls is recommended.

### Personal Protective Equipment: Respiratory

Not normally needed. If permissible levels are exceeded, use NIOSH approved dust respirator.

### Personal Protective Equipment: General

Use good hygiene practices when handling this material including changing and laundering work clothing after use.

## \*\*\* Section 9 - Physical & Chemical Properties \*\*\*

<b>Appearance:</b>	Clear	<b>Odor:</b>	Odorless
<b>Physical State:</b>	Solid (glass or particulate)	<b>pH:</b>	Not applicable
<b>Vapor Pressure:</b>	Not applicable	<b>Vapor Density:</b>	Not applicable
<b>Boiling Point:</b>	Not applicable	<b>Melting Point:</b>	Not applicable
<b>Solubility (H<sub>2</sub>O):</b>	Not applicable	<b>Specific Gravity:</b>	2.23 gm/cm <sup>3</sup>
<b>Freezing Point:</b>	Not applicable	<b>Particle Size:</b>	Not applicable
<b>Softening Point:</b>	821 deg C	<b>Evaporation Rate:</b>	Not applicable
<b>Viscosity:</b>	Not applicable	<b>Bulk Density:</b>	Not applicable
<b>Percent Volatile:</b>	Not applicable	<b>Molecular Weight:</b>	Not applicable

## Physical Properties: Additional Information

No information available.

## \*\*\* Section 10 - Chemical Stability & Reactivity Information \*\*\*

### Chemical Stability

Stable.

### Chemical Stability: Conditions to Avoid

None known.

### Incompatibility

None known.

### Hazardous Decomposition

At very high temperatures, irritating and toxic gaseous metallic oxides can be formed.

### Hazardous Polymerization

Will not occur.

## \*\*\* Section 11 - Toxicological Information \*\*\*

### Acute Toxicity

#### A: General Product Information

Dusts may cause mechanical irritation to eyes and skin. Ingestion may cause transient irritation of throat, stomach, and gastrointestinal tract. Inhalation may cause coughing, nose and throat irritation, and sneezing. Higher exposures may cause difficulty breathing, congestion, and chest tightness.

# Material Safety Data Sheet

Material Name : Glass Code 7740

ID: C-021

## B: Component Analysis - LD50/LC50

No LD50/LC50's are available for this product's components.

## Carcinogenicity

### A: General Product Information

No information available.

### B: Component Carcinogenicity

None of this product's components are listed by ACGIH, IARC, OSHA, NIOSH, or NTP.

## Epidemiology

No information available.

## Neurotoxicity

No information available.

## Mutagenicity

No information available.

## Teratogenicity

No information available.

## Other Toxicological Information

Under normal conditions of use for glass products, the likelihood of inhaling or ingesting amounts necessary for these effects to occur is very small.

## \*\*\* Section 12 - Ecological Information \*\*\*

## Ecotoxicity

### A: General Product Information

No information available.

### B: Component Analysis - Ecotoxicity - Aquatic Toxicity

No ecotoxicity data are available for this product's components.

## Environmental Fate

No information available.

## \*\*\* Section 13 - Disposal Considerations \*\*\*

## US EPA Waste Number & Descriptions

### A: General Product Information

No information available.

### B: Component Waste Numbers

No EPA Waste Numbers are applicable for this product's components.

## Disposal Instructions

You must test your waste using methods described in 40 CFR Part 261 to determine if it meets these or other applicable definitions of hazardous wastes. Waste must be handled in accordance with all applicable regulations. Glass products may be recycled.

## \*\*\* Section 14 - Transportation Information \*\*\*

## US DOT Information

**Shipping Name:** Not regulated as a hazardous material

**UN/NA #:** Not classified **Hazard Class:** Not classified **Packing Group:** Not classified

**Required Label(s):** None

**Additional Info.:** None

## International Transportation Regulations

This product is not regulated as a hazardous material by the United States (DOT) or Canadian (TDG) transportation regulations.

## \*\*\* Section 15 - Regulatory Information \*\*\*

## US Federal Regulations

### A: General Product Information

This product contains metal(s), which as dusts, fumes or particulates, is subject to the reporting requirements of Section 313 of SARA and its associated regulations. If the physical form and usage meets the definition of an article, no reporting is necessary. All components are on the U.S. EPA TSCA Inventory List.

# Material Safety Data Sheet

Material Name : Glass Code 7740

ID: C-021

## B: Component Analysis

None of this products components are listed under SARA Section 302 (40 CFR 355 Appendix A), SARA Section 313 (40 CFR 372.65), or CERCLA (40 CFR 302.4).

## State Regulations

### A: General Product Information

Other state regulations may apply. Check individual state requirements.

### B: Component Analysis - State

The following components appear on one or more of the following state hazardous substances lists:

Component	CAS	CA	FL	MA	MN	NJ	PA
Glass, oxide, chemicals	65997-17-3	No	No	No	Yes	No	No

## Other Regulations

### A: General Product Information

None identified.

### B: Component Analysis - Inventory

Component	CAS #	TSCA	DSL	EINECS
Glass, oxide, chemicals	65997-17-3	Yes	Yes	Yes

### C: Component Analysis - WHMIS IDL

No components are listed in the WHMIS IDL.

## \*\*\* Section 16 - Other Information \*\*\*

### Other Information

Reasonable care has been taken in the preparation of this information, but Corning makes no warranty of merchantability or any other warranty, expressed or implied, with respect to this information. Corning makes no representations and assumes no liability for any direct, incidental or consequential damages resulting from its use.

Revision information: Version 2.0000, 06-NOV-2002:  
Sections 1,2,3,4,5, 6,7,8,9,10,11,12,15,16  
were revised due to formulation/regulatory updates.

Previous issue: Version 1.0000, 13-JUN-1997

### Key/Legend

ACGIH = American Conference of Governmental Industrial Hygienists; CAS = Chemical Abstracts Service; CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act; CFR = Code of Federal Regulations; CPR = Controlled Products Regulations; DOT = Department of Transportation; DSL = Domestic Substances List; EINECS = European Inventory of Existing Commercial Chemical Substances; EPA = Environmental Protection Agency; IARC = International Agency for Research on Cancer; IATA = International Air Transport Association; mg/Kg = milligrams per Kilogram; mg/L = milligrams per Liter; mg/m3 = milligrams per Cubic Meter; MSHA = Mine Safety and Health Administration; NA = Not Applicable or Not Available; NIOSH = National Institute for Occupational Safety and Health; NJTSR = New Jersey Trade Secret Registry; NTP = National Toxicology Program; OSHA = Occupational Safety and Health Administration; SARA = Superfund Amendments and Reauthorization Act; TDG = Transport Dangerous Goods; TSCA = Toxic Substances Control Act; WHMIS = Workplace Hazardous Materials Information System.

This is the end of MSDS # C-021





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EZSmith.com

**Snap Set - Line20 - Gunmetal - (4pc)**

Stock# AV-DSNAP-L20-GUNMET-1

**SEE: QTY DISCOUNTS**

**Price: \$0.40**

**Designer Snap Set - Line20**  
**Gunmetal - (4pc)**

This is a designer line-20 snap set. It features a plain cap with a gunmetal finish. This look will add plenty of cool factor to any project. This set comes complete with the 4 pieces needed to make a fully functional snap assembly. (post, male, female, cap). These snaps can be used for leather, nylon, canvas, kydex, rubber and much more.

We recommend our [SSETL20 Snap Setter](#) for attaching this item.

**Specifications**

Designer Snap Set  
Model - Line20



Style - Plain Cap/Gunmetal Finish  
Post - (3/16)  
(4pc)



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Volume Discount Available		
	Price/Unit	
1-4	\$0.40	
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Customers who bought this product also purchased



KYDEX™ Thermoform Sheet Drill - (for Sheath/Holster Eyelets) - (#6)

\$8.99

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Punch Set - Medium - (3/16 to 5/16) - (8pc)

\$19.99

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Punch Set - Small - (5/64 to 11/64) - (8pc)



Eyelets - #6-9 (3/16) - Black Finish - (for .080-.093)

\$14.99

[View](#)

[Buy](#)



Belt Clip - Universal Sheath/Holster - Flush Mount w/holes - (Metal) - 1.75

\$2.99

[View](#)

[Buy](#)

KYDEX®/HOLSTEX®) - 100 Pack

\$7.74

[View](#)

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Chicago Screws - Black Oxide - #8 - (.1875 x .250) - 10 Pack

\$3.95

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**Associated Products You Maybe Interested In**



Snap Setter w/Anvil - Hand Setter - (for Sheath/Holster Snaps) - Line 20

\$11.99

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Leather - Tanned Hide - Black - (8-9oz) - (per/ft)

\$17.45

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Leather Die - 3D - (Cross)

\$4.99

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Eyelets - #8-8 (1/4) - Gunmetal Finish - (for .080 KYDEX®/HOLSTEX®) - 100 Pack

\$10.02

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Stamp Handle - Spring Loaded - (for 3D Stamping Dies)

\$6.99

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Snap Set - Line24 - Durable™ - Black - (4pc)

\$0.55

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 Wide Mouth Rectangular Bottle, Plastic, 500mL, Clear, 6 PK >

KARTELL

# Wide Mouth Rectangular Bottle, Plastic, 500mL, Clear, 6 PK

Item # 33N194 Mfr. Model # 226295-0500 Catalog Page # N/A UNSPSC # 41103209



Web Price ⓘ  
**\$27.74** / pkg. of 6

1

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Shipping Weight **0.7 lbs.**

Country of Origin Italy | *Country of Origin is subject to change.*

*Note: Product availability is real-time updated and adjusted continuously. The product will be reserved for you when you complete your order. [More](#)*

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## Product Details


This rectangular bottle is designed for storing a variety of substances. HDPE body construction helps to keep out moisture and other contaminants,

## Technical Specs

Item	Bottle	Labware Closure Liner Material	Polyethylene
Labware Capacity - English	16 oz.	Labware Closure Material	Polypropylene
Labware Capacity - Metric	500mL	Autoclavable	No
Mouth	Wide	Labware Body Color	Clear
Bottle/Jar Shape	Rectangular	Labware Closure Color	White Clear
Labware Basic Material	Plastic	Labware Depth - Metric	70mm
Labware Body Material	HDPE	Labware Width - Metric	80mm
Includes Closure	Yes	Special Features	Graduated, Rectangular/Square Bottle Design. Separate Internal Closure Plug For Additional Seal. Hole In Closure For Attachment of Tag.
Sterile/Non-Sterile	Non-Sterile	Graduation Subdivisions	100mL
Pre-Cleaned	None	Graduation Range	50 to 500mL
Labware Clarity	Translucent	Labware Height - English	5.4"
Labware Closure Type	Screw On	Labware Height - Metric	138mm





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## Compliance and Restrictions

None

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## Alternate Search Terms

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## SECTION FOUR – FIRE AND EXPLOSION DATA

<b>FLASHPOINT (METHOD):</b>	N/A
<b>CONDITIONS OF FLAMMABILITY:</b>	None
<b>EXTINGUISHING MEDIA:</b>	Required to extinguish surrounding fire. Water to cool radiation device holder.
<b>SPECIAL FIRE FIGHTING PROCEDURES:</b>	Intense heat may melt source containment housing causing release of radiation. Attempt to maintain a 30 meter safety zone from the fire impinged vehicle or source container. ** No excessive harmful results have been known to result from this type of packaging by the manufacturer or Trican Well Service.
<b>LOWER EXPLOSION LIMIT (% BY VOL):</b>	N/A
<b>UPPER EXPLOSION LIMIT (% BY VOL.):</b>	N/A
<b>AUTO-IGNITION TEMPERATURE:</b>	N/A
<b>HAZARDOUS COMBUSTION PRODUCTS:</b>	May release gamma radiation under very extreme conditions.
<b>SENSITIVITY TO STATIC DISCHARGE:</b>	NO
<b>SENSITIVITY TO MECHANICAL IMPACT:</b>	NO

## SECTION FIVE – REACTIVITY DATA

<b>CHEMICAL STABILITY:</b>	Stable, Half life of 30.2 years, principle mode of decay is beta particle emission. Maximum beta energy of 1.74 million electron volts. Gamma photon energies: 0.662 million electron volts; abundance 93.5%
<b>INCOMPATIBLE MATERIAL:</b>	N/A
<b>CONDITIONS OF REACTIVITY:</b>	N/A
<b>HAZARDOUS DECOMPOSITION PRODUCTS:</b>	Beta particle emissions.
<b>HAZARDOUS POLYMERIZATION:</b>	N/A

## SECTION SIX – TOXICOLOGICAL PROPERTIES

<b>ROUTES OF ENTRY:</b>	Inhalation, eyes, skin, ingestion
<b>ACCUTE OVER EXPOSURE EFFECTS:</b>	INHALATION – N/A  EYE CONTACT – N/A  SKIN CONTACT – Radioactive exposure of bare skin can result from prolonged contact exposure. Latent burns.  INGESTION – Radioactive exposure of internal organs can result from ingestion of metal.
<b>CHRONIC OVEREXPOSURE EFFECTS:</b>	May cause irritation/dermatitis. Cancer of the skin.
<b>SENSITIZATION:</b>	N/A
<b>CARCINOGENICITY:</b>	Prolonged exposure can be carcinogenic.
<b>MUTAGENICITY:</b>	N/A
<b>TERETOGENICITY:</b>	It is recommended that pregnant women not work with this material after the first trimester.

**REPRODUCTIVE TOXICITY:** N/A

**SYNERGISTIC PRODUCTS:** N/A

## **SECTION SEVEN – PREVENTATIVE MEASURES**

**PERSONAL PROTECTIVE EQUIPMENT:** Normal PPE for daily work. The ALARA principle of exposure to the product is to be maintained (keep exposure As Low As Reasonable Achievable .

**SPECIFIC ENGINEERING CONTROLS:** The source holder has been manufactured to withstand extreme conditions. Leak tests of source holders must be conducted yearly and analyzed. Radiation protection dictates that we minimize the time a person remains in the area of radiation as the amount of exposure occurs as a function of duration of exposure, less time means less exposure. Maximize the distance from the radiation source as the intensity of the radiation falls off sharply the further you are from the source. Use shielding wherever it is necessary to reduce or eliminate exposure.

**LEAK AND SPILL PROCEDURES:** **Follow recommendation outlined in the emergency response section of the Nuclear Gauge Transportation Manual (chapter 10)** Keep people away from the spill/accident site. Attempt to prevent further injury or loss. Report immediately to the appropriate supervisor. Record all pertinent information. Do NOT allow anyone to approach closer than 30meters of the source until a radioactive survey has been completed.

**WASTE DISPOSAL:** The Radiation Safety Officer or his designate will arrange for the removal and /or disposal of the damaged gauge.

**HANDLING/STORAGE REQUIRMENTS:** Handling and storage requirements of the Canadian Nuclear Safety Commission are to be adhered to. Only TRAINED PERSONEL are allowed to work with nuclear gauges.

**SPECIAL SHIPING INFORMATION:** Transportation of Nuclear Gauges is regulated under the Canadian Nuclear Safety Commission, Packaging and Transport of Nuclear Substances Regulations. Certain government licenses, documents, placards, labels and signs must be in place. Only workers trained in the transport of radioactive gauges will have care and control of nuclear a gauge.

## **SECTION EIGHT – FIRST AID MEASURES**

**INHALATION:** N/A

**INGESTION:** N/A

**EYES:** N/A

**SKIN:** N/A. Maximum permissible whole body dose equivalent for persons not classified as Atomic Radiation Workers is 0.005 sievert of radiation a year. If symptoms of radiation sickness (skin burns, excessive and rapid loss of hair) develops, see a physician immediately.

## SECTION NINE – CLASSIFICATION

**SHIPPING NAMES:** RADIOACTIVE MATERIAL, TYPE A PACKAGE, SPECIAL FORM.  
**TDGR Class (es):** Class 7, UN 3332, PG. II, ERAP – Not Required  
**WHMIS Class (es):** D2B  
**DSL:**

## SECTION TEN – PREPARATION INFORMATION

**Prepared by:** Trican Well Service Ltd. Phone Number: (403) 266-0202  
**Prepared on:** January 14, 2002  
**Supersedes:** July 23, 2005  
**Reviewed by:** Safety Publications Group

**References:** 1) Suppliers' Literature. 2) Trican Well Service research and Development. 3) NIOSH Pocket Guide to Chemical Hazards June, 1997. 4) The University of Vermont SIRC MSDS Archives. 5) TDGR Clear Language, October 2001.

“Information contained herein as been provided in good faith and reasonable efforts have been made to ensure its reliability, however, TRICAN WELL SERVICE LTD. accepts no liability for damage arising from the use of this information.”

END OF MATERIAL SAFETY DATA

---

**1. PRODUCT AND COMPANY IDENTIFICATION****1.1 Product identifiers**

Product name : L-Cysteine hydrochloride

Product Number : C1276

Brand : Sigma

CAS-No. : 52-89-1

**1.2 Relevant identified uses of the substance or mixture and uses advised against**

Identified uses : Laboratory chemicals, Synthesis of substances

**1.3 Details of the supplier of the safety data sheet**Company : Sigma-Aldrich  
3050 Spruce Street  
SAINT LOUIS MO 63103  
USA

Telephone : +1 800-325-5832

Fax : +1 800-325-5052

**1.4 Emergency telephone number**

Emergency Phone # : +1-703-527-3887 (CHEMTREC)

---

**2. HAZARDS IDENTIFICATION****2.1 Classification of the substance or mixture**

Not a hazardous substance or mixture.

**2.2 GHS Label elements, including precautionary statements**

Not a hazardous substance or mixture.

**2.3 Hazards not otherwise classified (HNOC) or not covered by GHS - none**

---

**3. COMPOSITION/INFORMATION ON INGREDIENTS****3.1 Substances**Formula :  $C_3H_7NO_2S \cdot HCl$ 

Molecular weight : 157.62 g/mol

CAS-No. : 52-89-1

EC-No. : 200-157-7

No components need to be disclosed according to the applicable regulations.

---

**4. FIRST AID MEASURES****4.1 Description of first aid measures****If inhaled**

If breathed in, move person into fresh air. If not breathing, give artificial respiration.



**In case of skin contact**

Wash off with soap and plenty of water.

**In case of eye contact**

Flush eyes with water as a precaution.

**If swallowed**

Never give anything by mouth to an unconscious person. Rinse mouth with water.

**4.2 Most important symptoms and effects, both acute and delayed**

The most important known symptoms and effects are described in the labelling (see section 2.2) and/or in section 11

**4.3 Indication of any immediate medical attention and special treatment needed**

No data available

---

**5. FIREFIGHTING MEASURES****5.1 Extinguishing media****Suitable extinguishing media**

Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

**5.2 Special hazards arising from the substance or mixture**

No data available

**5.3 Advice for firefighters**

Wear self-contained breathing apparatus for firefighting if necessary.

**5.4 Further information**

No data available

---

**6. ACCIDENTAL RELEASE MEASURES****6.1 Personal precautions, protective equipment and emergency procedures**

Avoid dust formation. Avoid breathing vapours, mist or gas.

For personal protection see section 8.

**6.2 Environmental precautions**

No special environmental precautions required.

**6.3 Methods and materials for containment and cleaning up**

Sweep up and shovel. Keep in suitable, closed containers for disposal.

**6.4 Reference to other sections**

For disposal see section 13.

---

**7. HANDLING AND STORAGE****7.1 Precautions for safe handling**

Further processing of solid materials may result in the formation of combustible dusts. The potential for combustible dust formation should be taken into consideration before additional processing occurs.

Provide appropriate exhaust ventilation at places where dust is formed.

For precautions see section 2.2.

**7.2 Conditions for safe storage, including any incompatibilities**

Keep container tightly closed in a dry and well-ventilated place.

Hygroscopic. Store under inert gas. Moisture sensitive. Air and light sensitive.

**7.3 Specific end use(s)**

Apart from the uses mentioned in section 1.2 no other specific uses are stipulated

---

**8. EXPOSURE CONTROLS/PERSONAL PROTECTION****8.1 Control parameters****Components with workplace control parameters**

Contains no substances with occupational exposure limit values.

## 8.2 Exposure controls

### Appropriate engineering controls

General industrial hygiene practice.

### Personal protective equipment

#### Eye/face protection

Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

#### Skin protection

Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Full contact

Material: Nitrile rubber

Minimum layer thickness: 0.11 mm

Break through time: 480 min

Material tested: Dermatril® (KCL 740 / Aldrich Z677272, Size M)

Splash contact

Material: Nitrile rubber

Minimum layer thickness: 0.11 mm

Break through time: 480 min

Material tested: Dermatril® (KCL 740 / Aldrich Z677272, Size M)

data source: KCL GmbH, D-36124 Eichenzell, phone +49 (0)6659 87300, e-mail sales@kcl.de, test method: EN374

If used in solution, or mixed with other substances, and under conditions which differ from EN 374, contact the supplier of the CE approved gloves. This recommendation is advisory only and must be evaluated by an industrial hygienist and safety officer familiar with the specific situation of anticipated use by our customers. It should not be construed as offering an approval for any specific use scenario.

#### Body Protection

Choose body protection in relation to its type, to the concentration and amount of dangerous substances, and to the specific work-place., The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

#### Respiratory protection

Respiratory protection is not required. Where protection from nuisance levels of dusts are desired, use type N95 (US) or type P1 (EN 143) dust masks. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

#### Control of environmental exposure

No special environmental precautions required.

---

## 9. PHYSICAL AND CHEMICAL PROPERTIES

### 9.1 Information on basic physical and chemical properties

- |  |  |
|--|--|
| a) Appearance                              | Form: Crystalline powder<br>Colour: white  |
| b) Odour                                   | No data available  |
| c) Odour Threshold                         | No data available  |
| d) pH                                      | No data available  |
| e) Melting point/freezing point            | Melting point/range: 174.1 - 174.7 °C (345.4 - 346.5 °F) - OECD Test Guideline 102 |
| f) Initial boiling point and boiling range | No data available  |
| g) Flash point                             | No data available  |
| h) Evaporation rate                        | No data available  |
| i) Flammability (solid, gas)               | No data available  |

j) Upper/lower flammability or explosive limits	No data available
k) Vapour pressure	No data available
l) Vapour density	No data available
m) Relative density	No data available
n) Water solubility	736.75 g/l at 20 °C (68 °F) - OECD Test Guideline 105 - completely soluble
o) Partition coefficient: n-octanol/water	No data available
p) Auto-ignition temperature	No data available
q) Decomposition temperature	No data available
r) Viscosity	No data available
s) Explosive properties	No data available
t) Oxidizing properties	No data available

## 9.2 Other safety information

No data available

---

## 10. STABILITY AND REACTIVITY

### 10.1 Reactivity

No data available

### 10.2 Chemical stability

Stable under recommended storage conditions.

### 10.3 Possibility of hazardous reactions

No data available

### 10.4 Conditions to avoid

May discolor on exposure to air and light. Avoid moisture.

### 10.5 Incompatible materials

Strong oxidizing agents, Metals

### 10.6 Hazardous decomposition products

Hazardous decomposition products formed under fire conditions. - Carbon oxides, Nitrogen oxides (NO<sub>x</sub>), Sulphur oxides, Hydrogen chloride gas

Other decomposition products - No data available

In the event of fire: see section 5

---

## 11. TOXICOLOGICAL INFORMATION

### 11.1 Information on toxicological effects

#### Acute toxicity

No data available

Inhalation: No data available

Dermal: No data available

LD50 Intravenous - Mouse - 771 mg/kg

LD50 Intraperitoneal - Mouse - 1,250 mg/kg

#### Skin corrosion/irritation

No data available

#### Serious eye damage/eye irritation

No data available

**Respiratory or skin sensitisation**

No data available

**Germ cell mutagenicity**

Mouse - male

Result: negative

**Carcinogenicity**

IARC: No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.

NTP: No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.

OSHA: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

**Reproductive toxicity**

No data available

No data available

**Specific target organ toxicity - single exposure**

No data available

**Specific target organ toxicity - repeated exposure**

No data available

**Aspiration hazard**

No data available

**Additional Information**

RTECS: HA2275000

To the best of our knowledge, the chemical, physical, and toxicological properties have not been thoroughly investigated.

---

**12. ECOLOGICAL INFORMATION****12.1 Toxicity**

No data available

**12.2 Persistence and degradability****12.3 Bioaccumulative potential**

No data available

**12.4 Mobility in soil**

No data available

**12.5 Results of PBT and vPvB assessment**

PBT/vPvB assessment not available as chemical safety assessment not required/not conducted

**12.6 Other adverse effects**

No data available

---

**13. DISPOSAL CONSIDERATIONS****13.1 Waste treatment methods****Product**

Offer surplus and non-recyclable solutions to a licensed disposal company.

**Contaminated packaging**

Dispose of as unused product.

---

**14. TRANSPORT INFORMATION****DOT (US)**

Not dangerous goods

**IMDG**

Not dangerous goods

**IATA**

Not dangerous goods

---

**15. REGULATORY INFORMATION**

**SARA 302 Components**

No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

**SARA 313 Components**

This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.

**SARA 311/312 Hazards**

No SARA Hazards

**Massachusetts Right To Know Components**

No components are subject to the Massachusetts Right to Know Act.

**Pennsylvania Right To Know Components**

	CAS-No.	Revision Date
L-Cysteine hydrochloride	52-89-1	

	CAS-No.	Revision Date
L-Cysteine hydrochloride	52-89-1	

**New Jersey Right To Know Components**

	CAS-No.	Revision Date
L-Cysteine hydrochloride	52-89-1	

**California Prop. 65 Components**

This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

---

**16. OTHER INFORMATION**

**HMIS Rating**

Health hazard:	0
Chronic Health Hazard:	
Flammability:	0
Physical Hazard	0

**NFPA Rating**

Health hazard:	0
Fire Hazard:	0
Reactivity Hazard:	0

**Further information**

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**Preparation Information**  
Sigma-Aldrich Corporation  
Product Safety – Americas Region  
1-800-521-8956

Version: 5.2

Revision Date: 05/07/2017

Print Date: 02/03/2018

## SAFETY DATA SHEET

Version 3.16  
Revision Date 01/14/2015  
Print Date 11/10/2018

### 1. PRODUCT AND COMPANY IDENTIFICATION

#### 1.1 Product identifiers

Product name : D-(+)-Glucose

Product Number : G7021

Brand : Sigma

CAS-No. : 50-99-7

#### 1.2 Relevant identified uses of the substance or mixture and uses advised against

Identified uses : Laboratory chemicals, Manufacture of substances

#### 1.3 Details of the supplier of the safety data sheet

Company : Sigma-Aldrich  
3050 Spruce Street  
SAINT LOUIS MO 63103  
USA

Telephone : +1 800-325-5832

Fax : +1 800-325-5052

#### 1.4 Emergency telephone number

Emergency Phone # : +1-703-527-3887 (CHEMTREC)

### 2. HAZARDS IDENTIFICATION

#### 2.1 Classification of the substance or mixture

Not a hazardous substance or mixture.

#### 2.2 GHS Label elements, including precautionary statements

Not a hazardous substance or mixture.

#### 2.3 Hazards not otherwise classified (HNOC) or not covered by GHS - none

### 3. COMPOSITION/INFORMATION ON INGREDIENTS

#### 3.1 Substances

Synonyms : Dextrose

Formula :  $C_6H_{12}O_6$

Molecular weight : 180.16 g/mol

CAS-No. : 50-99-7

EC-No. : 200-075-1

No components need to be disclosed according to the applicable regulations.

### 4. FIRST AID MEASURES

#### 4.1 Description of first aid measures

##### If inhaled

If breathed in, move person into fresh air. If not breathing, give artificial respiration.

##### In case of skin contact

Wash off with soap and plenty of water.

**In case of eye contact**

Flush eyes with water as a precaution.

**If swallowed**

Never give anything by mouth to an unconscious person. Rinse mouth with water.

**4.2 Most important symptoms and effects, both acute and delayed**

The most important known symptoms and effects are described in the labelling (see section 2.2) and/or in section 11

**4.3 Indication of any immediate medical attention and special treatment needed**

No data available

---

**5. FIREFIGHTING MEASURES****5.1 Extinguishing media****Suitable extinguishing media**

Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

**5.2 Special hazards arising from the substance or mixture**

Carbon oxides

**5.3 Advice for firefighters**

Wear self-contained breathing apparatus for firefighting if necessary.

**5.4 Further information**

No data available

---

**6. ACCIDENTAL RELEASE MEASURES****6.1 Personal precautions, protective equipment and emergency procedures**

Avoid dust formation. Avoid breathing vapours, mist or gas.  
For personal protection see section 8.

**6.2 Environmental precautions**

No special environmental precautions required.

**6.3 Methods and materials for containment and cleaning up**

Sweep up and shovel. Keep in suitable, closed containers for disposal.

**6.4 Reference to other sections**

For disposal see section 13.

---

**7. HANDLING AND STORAGE****7.1 Precautions for safe handling**

Further processing of solid materials may result in the formation of combustible dusts. The potential for combustible dust formation should be taken into consideration before additional processing occurs.  
Provide appropriate exhaust ventilation at places where dust is formed.  
For precautions see section 2.2.

**7.2 Conditions for safe storage, including any incompatibilities**

Keep container tightly closed in a dry and well-ventilated place.

hygroscopic Keep in a dry place.

Storage class (TRGS 510): Non Combustible Solids

**7.3 Specific end use(s)**

Apart from the uses mentioned in section 1.2 no other specific uses are stipulated

---

**8. EXPOSURE CONTROLS/PERSONAL PROTECTION****8.1 Control parameters****Components with workplace control parameters**

Contains no substances with occupational exposure limit values.



## 8.2 Exposure controls

### Appropriate engineering controls

General industrial hygiene practice.

### Personal protective equipment

#### Eye/face protection

Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

#### Skin protection

Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Full contact

Material: Nitrile rubber

Minimum layer thickness: 0.11 mm

Break through time: 480 min

Material tested: Dermatril® (KCL 740 / Aldrich Z677272, Size M)

Splash contact

Material: Nitrile rubber

Minimum layer thickness: 0.11 mm

Break through time: 480 min

Material tested: Dermatril® (KCL 740 / Aldrich Z677272, Size M)

data source: KCL GmbH, D-36124 Eichenzell, phone +49 (0)6659 87300, e-mail sales@kcl.de, test method: EN374

If used in solution, or mixed with other substances, and under conditions which differ from EN 374, contact the supplier of the CE approved gloves. This recommendation is advisory only and must be evaluated by an industrial hygienist and safety officer familiar with the specific situation of anticipated use by our customers. It should not be construed as offering an approval for any specific use scenario.

#### Body Protection

Choose body protection in relation to its type, to the concentration and amount of dangerous substances, and to the specific work-place., The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

#### Respiratory protection

Respiratory protection is not required. Where protection from nuisance levels of dusts are desired, use type N95 (US) or type P1 (EN 143) dust masks. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

#### Control of environmental exposure

No special environmental precautions required.

---

## 9. PHYSICAL AND CHEMICAL PROPERTIES

### 9.1 Information on basic physical and chemical properties

- |  |  |
|--|--|
| a) Appearance                              | Form: powder<br>Colour: white                    |
| b) Odour                                   | No data available                                |
| c) Odour Threshold                         | No data available                                |
| d) pH                                      | No data available                                |
| e) Melting point/freezing point            | Melting point/range: 150 - 152 °C (302 - 306 °F) |
| f) Initial boiling point and boiling range | No data available                                |
| g) Flash point                             | No data available                                |
| h) Evaporation rate                        | No data available                                |

- |   |                   |
|---|-------------------|
| i) Flammability (solid, gas)                    | No data available |
| j) Upper/lower flammability or explosive limits | No data available |
| k) Vapour pressure                              | No data available |
| l) Vapour density                               | No data available |
| m) Relative density                             | No data available |
| n) Water solubility                             | soluble           |
| o) Partition coefficient: n-octanol/water       | No data available |
| p) Auto-ignition temperature                    | No data available |
| q) Decomposition temperature                    | No data available |
| r) Viscosity                                    | No data available |
| s) Explosive properties                         | No data available |
| t) Oxidizing properties                         | No data available |

## 9.2 Other safety information

No data available

---

## 10. STABILITY AND REACTIVITY

### 10.1 Reactivity

No data available

### 10.2 Chemical stability

Stable under recommended storage conditions.

### 10.3 Possibility of hazardous reactions

No data available

### 10.4 Conditions to avoid

No data available

### 10.5 Incompatible materials

Strong oxidizing agents

### 10.6 Hazardous decomposition products

Other decomposition products - No data available

In the event of fire: see section 5

---

## 11. TOXICOLOGICAL INFORMATION

### 11.1 Information on toxicological effects

#### Acute toxicity

LD50 Oral - Rat - 25,800 mg/kg

Remarks: Behavioral:Coma. Cyanosis Diarrhoea

Inhalation: No data available

Dermal: No data available

No data available

#### Skin corrosion/irritation

No data available

#### Serious eye damage/eye irritation

No data available

**Respiratory or skin sensitisation**

No data available

**Germ cell mutagenicity**

Mouse

lymphocyte

Mutation in mammalian somatic cells.

**Carcinogenicity**

IARC: No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.

ACGIH: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by ACGIH.

NTP: No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.

OSHA: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

**Reproductive toxicity**

No data available

No data available

**Specific target organ toxicity - single exposure**

No data available

**Specific target organ toxicity - repeated exposure**

No data available

**Aspiration hazard**

No data available

**Additional Information**

RTECS: LZ6600000

To the best of our knowledge, the chemical, physical, and toxicological properties have not been thoroughly investigated.

---

**12. ECOLOGICAL INFORMATION****12.1 Toxicity**

No data available

**12.2 Persistence and degradability**

No data available

**12.3 Bioaccumulative potential**

No data available

**12.4 Mobility in soil**

No data available

**12.5 Results of PBT and vPvB assessment**

PBT/vPvB assessment not available as chemical safety assessment not required/not conducted

**12.6 Other adverse effects**

No data available

---

**13. DISPOSAL CONSIDERATIONS****13.1 Waste treatment methods****Product**

Offer surplus and non-recyclable solutions to a licensed disposal company.

**Contaminated packaging**  
Dispose of as unused product.

---

#### 14. TRANSPORT INFORMATION

**DOT (US)**

Not dangerous goods

**IMDG**

Not dangerous goods

**IATA**

Not dangerous goods

---

#### 15. REGULATORY INFORMATION

**SARA 302 Components**

No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

**SARA 313 Components**

This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.

**Massachusetts Right To Know Components**

No components are subject to the Massachusetts Right to Know Act.

**Pennsylvania Right To Know Components**

	CAS-No.	Revision Date
Glucose	50-99-7	

**New Jersey Right To Know Components**

	CAS-No.	Revision Date
Glucose	50-99-7	

**California Prop. 65 Components**

This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

---

#### 16. OTHER INFORMATION

**HMIS Rating**

Health hazard:	0
Chronic Health Hazard:	
Flammability:	0
Physical Hazard	0

**NFPA Rating**

Health hazard:	0
Fire Hazard:	0
Reactivity Hazard:	0

**Further information**

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**Preparation Information**  
Sigma-Aldrich Corporation  
Product Safety – Americas Region  
1-800-521-8956

Version: 3.16

Revision Date: 01/14/2015

Print Date: 11/10/2018

## SAFETY DATA SHEET

Version 3.12  
Revision Date 09/27/2017  
Print Date 11/10/2018

---

**1. PRODUCT AND COMPANY IDENTIFICATION****1.1 Product identifiers**

Product name : Carbon dioxide

Product Number : 295108

Brand : Aldrich

CAS-No. : 124-38-9

**1.2 Relevant identified uses of the substance or mixture and uses advised against**

Identified uses : Laboratory chemicals, Synthesis of substances

**1.3 Details of the supplier of the safety data sheet**

Company : Sigma-Aldrich  
3050 Spruce Street  
SAINT LOUIS MO 63103  
USA

Telephone : +1 800-325-5832

Fax : +1 800-325-5052

**1.4 Emergency telephone number**

Emergency Phone # : +1-703-527-3887 (CHEMTREC)

---

**2. HAZARDS IDENTIFICATION****2.1 Classification of the substance or mixture****GHS Classification in accordance with 29 CFR 1910 (OSHA HCS)**

Gases under pressure (Liquefied gas), H280

Simple Asphyxiant,

For the full text of the H-Statements mentioned in this Section, see Section 16.

**2.2 GHS Label elements, including precautionary statements**

Pictogram



Signal word

Warning

Hazard statement(s)

H280

Contains gas under pressure; may explode if heated.  
May displace oxygen and cause rapid suffocation.

Precautionary statement(s)

P410 + P403

Protect from sunlight. Store in a well-ventilated place.

**2.3 Hazards not otherwise classified (HNOC) or not covered by GHS - none**

---

**3. COMPOSITION/INFORMATION ON INGREDIENTS****3.1 Substances**

Formula : CO<sub>2</sub>

Molecular weight : 44.01 g/mol

CAS-No. : 124-38-9

EC-No. : 204-696-9

#### Hazardous components

Component	Classification	Concentration
<b>Carbon dioxide</b>	Press. Gas Liquefied gas; SA ; H280,	90 - 100 %

For the full text of the H-Statements mentioned in this Section, see Section 16.

---

#### 4. FIRST AID MEASURES

##### 4.1 Description of first aid measures

###### General advice

Consult a physician. Show this safety data sheet to the doctor in attendance. Move out of dangerous area.

###### If inhaled

If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.

###### In case of skin contact

Wash off with soap and plenty of water. Consult a physician.

###### In case of eye contact

Flush eyes with water as a precaution.

###### If swallowed

Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

##### 4.2 Most important symptoms and effects, both acute and delayed

The most important known symptoms and effects are described in the labelling (see section 2.2) and/or in section 11

##### 4.3 Indication of any immediate medical attention and special treatment needed

No data available

---

#### 5. FIREFIGHTING MEASURES

##### 5.1 Extinguishing media

###### Suitable extinguishing media

Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

##### 5.2 Special hazards arising from the substance or mixture

No data available

##### 5.3 Advice for firefighters

Wear self-contained breathing apparatus for firefighting if necessary.

##### 5.4 Further information

Use water spray to cool unopened containers.

---

#### 6. ACCIDENTAL RELEASE MEASURES

##### 6.1 Personal precautions, protective equipment and emergency procedures

Avoid breathing vapours, mist or gas. Ensure adequate ventilation. Evacuate personnel to safe areas. For personal protection see section 8.

##### 6.2 Environmental precautions

Do not let product enter drains.

##### 6.3 Methods and materials for containment and cleaning up

Clean up promptly by sweeping or vacuum.

##### 6.4 Reference to other sections

For disposal see section 13.

## 7. HANDLING AND STORAGE

### 7.1 Precautions for safe handling

For precautions see section 2.2.

### 7.2 Conditions for safe storage, including any incompatibilities

Keep container tightly closed in a dry and well-ventilated place.

Contents under pressure. Avoid heating above: 50°C

### 7.3 Specific end use(s)

Apart from the uses mentioned in section 1.2 no other specific uses are stipulated

## 8. EXPOSURE CONTROLS/PERSONAL PROTECTION

### 8.1 Control parameters

#### Components with workplace control parameters

Component	CAS-No.	Value	Control parameters	Basis
Carbon dioxide	124-38-9	TWA	5,000 ppm	USA. ACGIH Threshold Limit Values (TLV)
	Remarks	Asphyxia		
		TWA	5,000.000000 ppm	USA. ACGIH Threshold Limit Values (TLV)
		Asphyxia		
		STEL	30,000 ppm	USA. ACGIH Threshold Limit Values (TLV)
		Asphyxia		
		STEL	30,000.000000 ppm	USA. ACGIH Threshold Limit Values (TLV)
		Asphyxia		
		TWA	5,000.000000 ppm 9,000.000000 mg/m3	USA. Occupational Exposure Limits (OSHA) - Table Z-1 Limits for Air Contaminants
		The value in mg/m3 is approximate.		
		TWA	5,000.000000 ppm 9,000.000000 mg/m3	USA. NIOSH Recommended Exposure Limits
		Normal constituent of air (about 300 ppm).		
		ST	30,000.000000 ppm 54,000.000000 mg/m3	USA. NIOSH Recommended Exposure Limits
		Normal constituent of air (about 300 ppm).		
		TWA	5,000 ppm 9,000 mg/m3	USA. NIOSH Recommended Exposure Limits
		Normal constituent of air (about 300 ppm).		
		ST	30,000 ppm 54,000 mg/m3	USA. NIOSH Recommended Exposure Limits
		Normal constituent of air (about 300 ppm).		
		TWA	5,000 ppm 9,000 mg/m3	USA. Occupational Exposure Limits (OSHA) - Table Z-1 Limits for Air Contaminants
		The value in mg/m3 is approximate.		



		PEL	5,000 ppm 9,000 mg/m <sup>3</sup>	California permissible exposure limits for chemical contaminants (Title 8, Article 107)
		STEL	30,000 ppm 54,000 mg/m <sup>3</sup>	California permissible exposure limits for chemical contaminants (Title 8, Article 107)

## 8.2 Exposure controls

### Appropriate engineering controls

Handle in accordance with good industrial hygiene and safety practice. Wash hands before breaks and at the end of workday.

### Personal protective equipment

#### Eye/face protection

Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

#### Skin protection

Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

#### Full contact

Material: butyl-rubber

Minimum layer thickness: 0.3 mm

Break through time: 480 min

Material tested: Butoject® (KCL 897 / Aldrich Z677647, Size M)

#### Splash contact

Material: Chloroprene

Minimum layer thickness: 0.6 mm

Break through time: 30 min

Material tested: Camapren® (KCL 722 / Aldrich Z677493, Size M)

data source: KCL GmbH, D-36124 Eichenzell, phone +49 (0)6659 87300, e-mail sales@kcl.de, test method: EN374

If used in solution, or mixed with other substances, and under conditions which differ from EN 374, contact the supplier of the CE approved gloves. This recommendation is advisory only and must be evaluated by an industrial hygienist and safety officer familiar with the specific situation of anticipated use by our customers. It should not be construed as offering an approval for any specific use scenario.

#### Body Protection

Impervious clothing, The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

#### Respiratory protection

Where risk assessment shows air-purifying respirators are appropriate use a full-face respirator with multi-purpose combination (US) or type AXBEK (EN 14387) respirator cartridges as a backup to engineering controls. If the respirator is the sole means of protection, use a full-face supplied air respirator. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

#### Control of environmental exposure

Do not let product enter drains.

## 9. PHYSICAL AND CHEMICAL PROPERTIES

### 9.1 Information on basic physical and chemical properties

- |                           |  |
|---------------------------|--|
| a) Appearance             | Form: Liquefied gas                              |
| b) Odour                  | No data available                                |
| c) Odour Threshold        | No data available                                |
| d) pH                     | No data available                                |
| e) Melting point/freezing | Melting point/range: -78.5 °C (-109.3 °F) - lit. |

point

f) Initial boiling point and boiling range	No data available
g) Flash point	Not applicable
h) Evaporation rate	No data available
i) Flammability (solid, gas)	No data available
j) Upper/lower flammability or explosive limits	No data available
k) Vapour pressure	57,249 hPa (42,940 mmHg) at 20 °C (68 °F)
l) Vapour density	1.52 - (Air = 1.0)
m) Relative density	No data available
n) Water solubility	No data available
o) Partition coefficient: n-octanol/water	No data available
p) Auto-ignition temperature	No data available
q) Decomposition temperature	No data available
r) Viscosity	No data available
s) Explosive properties	No data available
t) Oxidizing properties	No data available

## 9.2 Other safety information

Sublimation point -78.49 °C

Relative vapour density 1.52 - (Air = 1.0)

---

## 10. STABILITY AND REACTIVITY

### 10.1 Reactivity

No data available

### 10.2 Chemical stability

Stable under recommended storage conditions.

### 10.3 Possibility of hazardous reactions

No data available

### 10.4 Conditions to avoid

No data available

### 10.5 Incompatible materials

No data available

### 10.6 Hazardous decomposition products

Hazardous decomposition products formed under fire conditions. - Carbon oxides

Other decomposition products - No data available

In the event of fire: see section 5

---

## 11. TOXICOLOGICAL INFORMATION

### 11.1 Information on toxicological effects

#### Acute toxicity

No data available

Inhalation: No data available

Dermal: No data available

No data available

**Skin corrosion/irritation**

No data available

**Serious eye damage/eye irritation**

No data available

**Respiratory or skin sensitisation**

No data available

**Germ cell mutagenicity**

No data available

**Carcinogenicity**

IARC: No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.

NTP: No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.

OSHA: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

**Reproductive toxicity**

No data available

No data available

**Specific target organ toxicity - single exposure**

No data available

**Specific target organ toxicity - repeated exposure**

No data available

**Aspiration hazard**

No data available

**Additional Information**

RTECS: FF6400000

Nausea, Dizziness, Headache, Low to medium concentrations of carbon dioxide can:, affect regulation of blood circulation, affect the acidity of body fluids, respiratory difficulties, At high concentrations:, Breathing difficulties, Increased pulse rate, change in body acidity, Very high concentrations can cause:, Unconsciousness, death

---

**12. ECOLOGICAL INFORMATION**

**12.1 Toxicity**

No data available

**12.2 Persistence and degradability**

No data available

**12.3 Bioaccumulative potential**

No data available

**12.4 Mobility in soil**

No data available

**12.5 Results of PBT and vPvB assessment**

PBT/vPvB assessment not available as chemical safety assessment not required/not conducted

**12.6 Other adverse effects**

No data available

---

## 13. DISPOSAL CONSIDERATIONS

### 13.1 Waste treatment methods

#### Product

Offer surplus and non-recyclable solutions to a licensed disposal company. Contact a licensed professional waste disposal service to dispose of this material.

#### Contaminated packaging

Dispose of as unused product.

---

## 14. TRANSPORT INFORMATION

### DOT (US)

UN number: 1013      Class: 2.2  
Proper shipping name: Carbon dioxide  
Reportable Quantity (RQ):  
Poison Inhalation Hazard: No

### IMDG

UN number: 1013      Class: 2.2      EMS-No: F-C, S-V  
Proper shipping name: CARBON DIOXIDE

### IATA

UN number: 1013      Class: 2.2  
Proper shipping name: Carbon dioxide

---

## 15. REGULATORY INFORMATION

### SARA 302 Components

No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

### SARA 313 Components

This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.

### Massachusetts Right To Know Components

	CAS-No.	Revision Date
Carbon dioxide	124-38-9	1993-04-24

### Pennsylvania Right To Know Components

	CAS-No.	Revision Date
Carbon dioxide	124-38-9	1993-04-24

### New Jersey Right To Know Components

	CAS-No.	Revision Date
Carbon dioxide	124-38-9	1993-04-24

### California Prop. 65 Components

This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

---

## 16. OTHER INFORMATION

### Full text of H-Statements referred to under sections 2 and 3.

H280	May displace oxygen and cause rapid suffocation.
Press. Gas	Contains gas under pressure; may explode if heated.
SA	Gases under pressure
	Simple Asphyxiant

### HMIS Rating

Health hazard:                      0  
Chronic Health Hazard:

Flammability: 1  
Physical Hazard 1

**NFPA Rating**

Health hazard: 0  
Fire Hazard: 0  
Reactivity Hazard: 0

**Further information**

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**Preparation Information**

Sigma-Aldrich Corporation  
Product Safety – Americas Region  
1-800-521-8956

Version: 3.12

Revision Date: 09/27/2017

Print Date: 11/10/2018

## SAFETY DATA SHEET

Version 3.11  
Revision Date 09/27/2017  
Print Date 11/10/2018

### 1. PRODUCT AND COMPANY IDENTIFICATION

#### 1.1 Product identifiers

Product name : Hydrogen  
  
Product Number : 295396  
Brand : Aldrich  
Index-No. : 001-001-00-9  
  
CAS-No. : 1333-74-0

#### 1.2 Relevant identified uses of the substance or mixture and uses advised against

Identified uses : Laboratory chemicals, Synthesis of substances

#### 1.3 Details of the supplier of the safety data sheet

Company : Sigma-Aldrich  
3050 Spruce Street  
SAINT LOUIS MO 63103  
USA  
  
Telephone : +1 800-325-5832  
Fax : +1 800-325-5052

#### 1.4 Emergency telephone number

Emergency Phone # : +1-703-527-3887 (CHEMTREC)

### 2. HAZARDS IDENTIFICATION

#### 2.1 Classification of the substance or mixture

##### GHS Classification in accordance with 29 CFR 1910 (OSHA HCS)

Flammable gases (Category 1), H220  
Gases under pressure (Compressed gas), H280  
Simple Asphyxiant,

For the full text of the H-Statements mentioned in this Section, see Section 16.

#### 2.2 GHS Label elements, including precautionary statements

Pictogram



Signal word

Danger

Hazard statement(s)

H220 Extremely flammable gas.  
H280 Contains gas under pressure; may explode if heated.  
May displace oxygen and cause rapid suffocation.

Precautionary statement(s)

P210 Keep away from heat/sparks/open flames/hot surfaces. No smoking.  
P377 Leaking gas fire: Do not extinguish, unless leak can be stopped safely.  
P381 Eliminate all ignition sources if safe to do so.  
P410 + P403 Protect from sunlight. Store in a well-ventilated place.

#### 2.3 Hazards not otherwise classified (HNOC) or not covered by GHS - none

---

### 3. COMPOSITION/INFORMATION ON INGREDIENTS

#### 3.1 Substances

Formula : H<sub>2</sub>  
Molecular weight : 2.02 g/mol  
CAS-No. : 1333-74-0  
EC-No. : 215-605-7  
Index-No. : 001-001-00-9

#### Hazardous components

Component	Classification	Concentration
Hydrogen	Flam. Gas 1; Press. Gas Compr. Gas; SA ; H220, H280,	90 - 100 %

For the full text of the H-Statements mentioned in this Section, see Section 16.

---

### 4. FIRST AID MEASURES

#### 4.1 Description of first aid measures

##### General advice

Consult a physician. Show this safety data sheet to the doctor in attendance. Move out of dangerous area.

##### If inhaled

If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.

##### In case of skin contact

Wash off with soap and plenty of water. Consult a physician.

##### In case of eye contact

Flush eyes with water as a precaution.

##### If swallowed

Do NOT induce vomiting. Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

#### 4.2 Most important symptoms and effects, both acute and delayed

The most important known symptoms and effects are described in the labelling (see section 2.2) and/or in section 11

#### 4.3 Indication of any immediate medical attention and special treatment needed

No data available

---

### 5. FIREFIGHTING MEASURES

#### 5.1 Extinguishing media

##### Suitable extinguishing media

Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

#### 5.2 Special hazards arising from the substance or mixture

No data available

#### 5.3 Advice for firefighters

Wear self-contained breathing apparatus for firefighting if necessary.

#### 5.4 Further information

Use water spray to cool unopened containers.

---

## 6. ACCIDENTAL RELEASE MEASURES

### 6.1 Personal precautions, protective equipment and emergency procedures

Avoid breathing vapours, mist or gas. Ensure adequate ventilation. Remove all sources of ignition. Evacuate personnel to safe areas. Beware of vapours accumulating to form explosive concentrations. Vapours can accumulate in low areas.

For personal protection see section 8.

### 6.2 Environmental precautions

Prevent further leakage or spillage if safe to do so. Do not let product enter drains.

### 6.3 Methods and materials for containment and cleaning up

Clean up promptly by sweeping or vacuum.

### 6.4 Reference to other sections

For disposal see section 13.

---

## 7. HANDLING AND STORAGE

### 7.1 Precautions for safe handling

Avoid inhalation of vapour or mist.

Use explosion-proof equipment. Keep away from sources of ignition - No smoking. Take measures to prevent the build up of electrostatic charge.

For precautions see section 2.2.

### 7.2 Conditions for safe storage, including any incompatibilities

Keep container tightly closed in a dry and well-ventilated place.

Contents under pressure.

### 7.3 Specific end use(s)

Apart from the uses mentioned in section 1.2 no other specific uses are stipulated

---

## 8. EXPOSURE CONTROLS/PERSONAL PROTECTION

### 8.1 Control parameters

#### Components with workplace control parameters

Contains no substances with occupational exposure limit values.

	Remarks	
		Asphyxia See Notice of Intended Changes (NIC) Simple asphyxiant; see discussion covering Minimal Oxygen Content found in the 'Definitions and Notations' section following the NIC tables
		See Appendix F: Minimal Oxygen Content Asphyxia 2015 Adoption Simple asphyxiant; see discussion covering Minimal Oxygen Content found in the 'Definitions and Notations' section following the NIC tables

Hazardous components without workplace control parameters

### 8.2 Exposure controls

#### Appropriate engineering controls

Handle in accordance with good industrial hygiene and safety practice. Wash hands before breaks and at the end of workday.

#### Personal protective equipment

##### Eye/face protection

Face shield and safety glasses Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).



### Skin protection

Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Splash contact

Material: butyl-rubber

Minimum layer thickness: 0.3 mm

Break through time: 120 min

Material tested: Butoject® (KCL 897 / Aldrich Z677647, Size M)

data source: KCL GmbH, D-36124 Eichenzell, phone +49 (0)6659 87300, e-mail sales@kcl.de, test method: EN374

If used in solution, or mixed with other substances, and under conditions which differ from EN 374, contact the supplier of the CE approved gloves. This recommendation is advisory only and must be evaluated by an industrial hygienist and safety officer familiar with the specific situation of anticipated use by our customers. It should not be construed as offering an approval for any specific use scenario.

### Body Protection

Impervious clothing, Flame retardant antistatic protective clothing., The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

### Respiratory protection

Where risk assessment shows air-purifying respirators are appropriate use a full-face respirator with multi-purpose combination (US) or type AXBEK (EN 14387) respirator cartridges as a backup to engineering controls. If the respirator is the sole means of protection, use a full-face supplied air respirator. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

### Control of environmental exposure

Prevent further leakage or spillage if safe to do so. Do not let product enter drains.

---

## 9. PHYSICAL AND CHEMICAL PROPERTIES

### 9.1 Information on basic physical and chemical properties

- |   |   |
|---|---|
| a) Appearance                                   | Form: Compressed gas<br>Colour: colourless                        |
| b) Odour  | No data available   |
| c) Odour Threshold                              | No data available   |
| d) pH   | No data available   |
| e) Melting point/freezing point                 | Melting point/range: -259.2 °C (-434.6 °F) - lit.                 |
| f) Initial boiling point and boiling range      | -252.8 °C (-423.0 °F) - lit.                                      |
| g) Flash point                                  | < -150 °C (< -238 °F) - closed cup                                |
| h) Evaporation rate                             | No data available   |
| i) Flammability (solid, gas)                    | No data available   |
| j) Upper/lower flammability or explosive limits | Upper explosion limit: 74.2 %(V)<br>Lower explosion limit: 4 %(V) |
| k) Vapour pressure                              | No data available   |
| l) Vapour density                               | 0.08  |
| m) Relative density                             | No data available   |
| n) Water solubility                             | 0.00196 g/l at 0 °C (32 °F)                                       |
| o) Partition coefficient: n-octanol/water       | No data available   |
| p) Auto-ignition                                | No data available   |

temperature

- q) Decomposition temperature No data available
- r) Viscosity No data available
- s) Explosive properties No data available
- t) Oxidizing properties No data available

## 9.2 Other safety information

Relative vapour density 0.08

---

## 10. STABILITY AND REACTIVITY

### 10.1 Reactivity

No data available

### 10.2 Chemical stability

Stable under recommended storage conditions.

### 10.3 Possibility of hazardous reactions

No data available

### 10.4 Conditions to avoid

Heat, flames and sparks.

### 10.5 Incompatible materials

Oxidizing agents

### 10.6 Hazardous decomposition products

Other decomposition products - No data available  
In the event of fire: see section 5

---

## 11. TOXICOLOGICAL INFORMATION

### 11.1 Information on toxicological effects

#### Acute toxicity

No data available

Inhalation: No data available

Dermal: No data available

No data available

#### Skin corrosion/irritation

No data available

#### Serious eye damage/eye irritation

No data available

#### Respiratory or skin sensitisation

No data available

#### Germ cell mutagenicity

No data available

#### Carcinogenicity

IARC: No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.

NTP: No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.

OSHA: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

#### Reproductive toxicity

No data available

No data available

**Specific target organ toxicity - single exposure**

No data available

**Specific target organ toxicity - repeated exposure**

No data available

**Aspiration hazard**

No data available

**Additional Information**

RTECS: MW8900000

To the best of our knowledge, the chemical, physical, and toxicological properties have not been thoroughly investigated.

---

**12. ECOLOGICAL INFORMATION**

**12.1 Toxicity**

No data available

**12.2 Persistence and degradability**

No data available

**12.3 Bioaccumulative potential**

No data available

**12.4 Mobility in soil**

No data available

**12.5 Results of PBT and vPvB assessment**

PBT/vPvB assessment not available as chemical safety assessment not required/not conducted

**12.6 Other adverse effects**

No data available

---

**13. DISPOSAL CONSIDERATIONS**

**13.1 Waste treatment methods**

**Product**

Contact a licensed professional waste disposal service to dispose of this material. Burn in a chemical incinerator equipped with an afterburner and scrubber but exert extra care in igniting as this material is highly flammable. Offer surplus and non-recyclable solutions to a licensed disposal company.

**Contaminated packaging**

Dispose of as unused product.

---

**14. TRANSPORT INFORMATION**

**DOT (US)**

UN number: 1049      Class: 2.1  
Proper shipping name: Hydrogen, compressed  
Reportable Quantity (RQ):  
Poison Inhalation Hazard: No

**IMDG**

UN number: 1049      Class: 2.1  
Proper shipping name: HYDROGEN, COMPRESSED

EMS-No: F-D, S-U

**IATA**

UN number: 1049      Class: 2.1  
Proper shipping name: Hydrogen, compressed  
IATA Passenger: Not permitted for transport

---

## 15. REGULATORY INFORMATION

### SARA 302 Components

No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

### SARA 313 Components

This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.

### Massachusetts Right To Know Components

	CAS-No.	Revision Date
Hydrogen	1333-74-0	1993-04-24

### Pennsylvania Right To Know Components

	CAS-No.	Revision Date
Hydrogen	1333-74-0	1993-04-24

### New Jersey Right To Know Components

	CAS-No.	Revision Date
Hydrogen	1333-74-0	1993-04-24

### California Prop. 65 Components

This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

---

## 16. OTHER INFORMATION

### Full text of H-Statements referred to under sections 2 and 3.

Flam. Gas	May displace oxygen and cause rapid suffocation.
H220	Flammable gases
H280	Extremely flammable gas.
Press. Gas	Contains gas under pressure; may explode if heated.
SA	Gases under pressure
	Simple Asphyxiant

### HMIS Rating

Health hazard:	0
Chronic Health Hazard:	
Flammability:	4
Physical Hazard	3

### NFPA Rating

Health hazard:	0
Fire Hazard:	4
Reactivity Hazard:	0

### Further information

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### Preparation Information

Sigma-Aldrich Corporation  
Product Safety – Americas Region  
1-800-521-8956

Version: 3.11

Revision Date: 09/27/2017

Print Date: 11/10/2018



## Thomas A Christensen II

---

**From:** Madeline Jean Dalrymple  
**Sent:** Monday, January 29, 2018 4:47 PM  
**To:** Thomas A Christensen II  
**Cc:** Neil M. Day  
**Subject:** Shipping Fuel Cells Containing Rumen  
**Attachments:** [REDACTED] (43 seconds) Voice Mail.mp3  
**Categories:** ~ChemE Car

Hi Thomas

Thanks you for contacting me about shipping fuel cells that contain rumen. I have cc-ed Neil Day, UW's supervisor of the Regulated Materials Management Center. He advises on shipping regulated materials as well.

Thomas, here is a summary of our phone conversation.

The rumen has microorganisms present but is not considered pathogenic. Also because it does not contain genetically modified organism, and has no preservative it is not regulated. [https://pe.usps.com/text/imm/immc1\\_014.htm#ep1001704](https://pe.usps.com/text/imm/immc1_014.htm#ep1001704)

Therefore the concern would be to triple pack it in order to contain all liquid contents in case the fuel cell leaks.

Here is a link on packing [https://pe.usps.com/text/pub52/pub52apxc\\_023.htm](https://pe.usps.com/text/pub52/pub52apxc_023.htm) or here [http://www.fedex.com/us/packaging/guides/Clinical\\_fxcom.pdf](http://www.fedex.com/us/packaging/guides/Clinical_fxcom.pdf)

About the fragility of the sample stoppers and keeping the sample warm, others may be of service, especially the company you may ship with such as Fed Ex.

I am glad to further discuss.

Good luck with your project!

Madeline Dalrymple

Biological Safety Specialist, MS, RBP, Responsible Official for Select Agents  
University of Wyoming, Office of Research and Economic Development  
Laramie, WY 82071, [USA](http://USA)  
Desk: 307-766-2723, [mjd@uwyo.edu](mailto:mjd@uwyo.edu)

---

**From:** Microsoft Outlook **On Behalf Of** [REDACTED]  
**Sent:** Monday, January 29, 2018 3:52 PM  
**To:** Madeline Jean Dalrymple <Dalrympl@uwyo.edu>  
**Subject:** Voice Mail (43 seconds)

Hello this is Thomas Christensen and we returning your call I called you on Friday regarding shipping room and four led to another university I would be available anytime.

From here until five -- today and Monday for five class and so -- 12:30 tomorrow Tuesday but would be available to talk anytime after that -- my number is [REDACTED] -- thank you for getting back to me and I hope to talk to you soon.

HM.

Preview provided by Microsoft Speech Technology. [Learn More...](#)

---

## Thomas A Christensen II

---

**From:** Sarah Ewing <sarae@aiche.org>  
**Sent:** Monday, February 27, 2017 8:08 AM  
**To:** Thomas A Christensen II  
**Subject:** RE: ChemE Car Competition Rules Clarification

**Categories:** ~AICHE

Thomas, this is the response I got from our safety coordinator, they need more information

*The premise of this idea is within the bounds of the rules, as I can see it, however my concern is regarding the at present, unidentified radioactive source. We need to know which chemicals they are planning to use, and they must follow the NFPA rules requirements. There may also be shipping regulations to deal with. See rules sections on regulated chemicals and highly reactive / unstable chemicals attached.*

*Please have the students email more info if they want a specific ruling on the reaction chemistry before proceeding.*

Best,

**Sarah Ewing**  
Senior Membership Associate, Student Programs  
[sarae@aiche.org](mailto:sarae@aiche.org)  
646-495-1364

---

**From:** Thomas A Christensen II [mailto:tchris13@uwyo.edu]  
**Sent:** Thursday, February 23, 2017 8:20 PM  
**To:** Studentchapters  
**Subject:** ChemE Car Competition Rules Clarification

To Whom It May Concern,

I am the captain of our AIChE's ChemE car team at the University of Wyoming. We are in the process of designing a car to be entered in the 2018 regional competition, and could not determine if one of our ideas complied with the rules of the contest or not. We would like to have our timer reaction be based upon the decay of a radioactive source, which is then shielded from a Geiger counter by a variable amount of aluminum shields. The Geiger counter would then be set to cut power to the engine when a pre-specified number of particles have been measured by it. We believe that this fits within the criteria of "direct control of the concentration of a chemical species," that species being alpha- or beta-particles, but wanted to clarify and make sure that would be considered legitimate at the contest before proceeding further with our design. Would this stopping system, as I have described it, be allowed to compete at the regional ChemE car competition? Thank you for your time and input. I look forward to your reply.

Sincerely,  
Thomas A. Christensen II  
[tchris13@uwyo.edu](mailto:tchris13@uwyo.edu)

*"Once you get into your higher-level classes, you pay a lot of money, and you have to use a fancy vocabulary." ~ C. Angevine*

*"College Education: something that shows a man how little other people know." ~ T. C. Haliburton*

**University of Wyoming AICHe ChemE Car 2018**  
**Absorbed Dose Justification for <sup>137</sup>Cs**

The exposure rate from a radioactive source is given by

$$\frac{X}{t} = \frac{\Gamma A}{d^2}$$

Where  $X/t$  is the exposure per time,  $\Gamma$  is the exposure rate constant and  $A$  is the activity for the radioactive source in question, and  $d$  is the distance from the source at which exposure is measured [1]. For <sup>137</sup>Cs,  $\Gamma=3.28 \text{ R cm}^2 \text{ mCi}^{-1} \text{ hr}^{-1}$  [2]. Therefore, assuming that the operator stands an overly conservative average of 10 cm away from the  $10 \mu\text{Ci}$  <sup>137</sup>Cs source equipped in the ChemE Car, the exposure rate would be

$$\frac{X}{t} = \frac{3.28 \frac{\text{R cm}^2}{\text{mCi hr}} 10 \times 10^{-3} \text{mCi}}{(10 \text{ cm})^2} = 3.28 \times 10^{-4} \frac{\text{R}}{\text{hr}}$$

1 R corresponds to an absorbed dose of 0.00873 Gy [1]. Therefore

$$3.28 \times 10^{-4} \frac{\text{R}}{\text{hr}} \times \frac{0.00873 \text{ Gy}}{1 \text{ R}} = 2.86 \times 10^{-6} \frac{\text{Gy}}{\text{hr}}$$

For gamma radiation, 1 Gy absorbed dose is equivalent to 1 Sv of effective and equivalent dose [3]. NRC regulations permit an individual to receive 0.5 Sv of effective dose though occupational work per year [4]. Using the effective dose as a conversion:

$$0.5 \text{ Sv} \div 2.86 \times 10^{-6} \frac{\text{Sv}}{\text{hr}} = 1.75 \times 10^5 \text{ hr} = 19.9 \text{ yr}$$

Therefore, it would require 20 years of continuous exposure to receive the occupational limit set for one year by the NRC.

### References

1. **Johns, H. E. and J. R. Cunningham.** "The physics of radiology." 4<sup>th</sup> Ed. Charles Thomas and Company. Springfield, IL (1983).
2. **Jani, S. K.** "Handbook of dosimetry data for radiotherapy.": CRC Press, Boca Raton (1993).
3. **Wahlström, B.** "Understanding radiation.": Medical Physics Pub, Madison WI (1995).
4. **US Nuclear Regulatory Commission.** "Occupational Dose Limits." <https://www.nrc.gov/reading-rm/doc-collections/cfr/part020/part020-1201.html>, NRC, Washington, DC, May 1991.





## 2019 MANAGEMENT OF CHANGE REQUEST FORM

Name of Person or Group Requesting Change: \_\_\_\_\_ Date: \_\_\_\_\_

Summary Description of Change:

Reason(s) for Change:

Change is:  permanent  
 temporary      Duration of change: \_\_\_\_\_

Signature of Requestor: \_\_\_\_\_

Attachment checklist:	Yes	N/A
	<input type="checkbox"/>	<input type="checkbox"/> Updated Process Flow Sheet, if changed
	<input type="checkbox"/>	<input type="checkbox"/> Current Process Flow Sheet
	<input type="checkbox"/>	<input type="checkbox"/> Updated JSA pages, if changed
	<input type="checkbox"/>	<input type="checkbox"/> Current JSA pages
	<input type="checkbox"/>	<input type="checkbox"/> Updated Engineering documentation pages, if changed
	<input type="checkbox"/>	<input type="checkbox"/> Current Engineering documentation pages
	<input type="checkbox"/>	<input type="checkbox"/> Safety Evaluation Checklist (req'd. – see below)

**Management of Change Request Form**

**PROCESS CHANGE REQUEST  
APPROVAL FORM**

**Type of Change:**       Major – Requires review by entire team and faculty adviser  
                                  Minor – Requires review by team only

**Description of Change as Approved:**

**Approved Duration of Change:** \_\_\_\_\_

**Signatures of Approval**

Faculty Adviser: \_\_\_\_\_ Date: \_\_\_\_\_

Review Team Member: \_\_\_\_\_ Date: \_\_\_\_\_

Review Team Member: \_\_\_\_\_ Date: \_\_\_\_\_

Review Team Member: \_\_\_\_\_ Date: \_\_\_\_\_

Review Team Member: \_\_\_\_\_ Date: \_\_\_\_\_

Review Team Member: \_\_\_\_\_ Date: \_\_\_\_\_

Review Team Member: \_\_\_\_\_ Date: \_\_\_\_\_

**Attach minutes and pertinent notes from review team meetings and place in permanent file.**

## Management of Change Request Form

### SAFETY EVALUATION CHECKLIST

Complete this safety evaluation checklist, noting any conditions that apply to the proposed change. Attach a more detailed description of the change, if necessary, along with all supporting materials.

#### Changes in Process Conditions/Materials:

- temperature
- pressure
- flow
- level
- composition
- chemical
- toxicity
- flash point
- reaction conditions
- biohazard
- use of regulated materials
- use of lasers/ change in class of lasers

#### Changes in Operating Conditions/ Procedures:

- startup
- normal operations
- abnormal operations
- shut down
- emergency shut down
- maintenance procedures
- lock-out
- tagging

#### Changes in Process Equipment:

- size or capacity
- materials of construction
- seals and gasket materials
- piping/ valving
- electrical system
- max./min. working pressure
- max./min. working temperature
- equipment guarding
- thermal insulation/insulation coverings
- filters
- support structures

#### Changes in Facilities:

- ventilation
- lighting
- utility services
- building modifications/renovations

#### Changes in Safety Equipment:

- containment
- guarding
- fire protection
- fire detection
- safety equipment location
- safety equipment type
- personal protective equipment
- grounding/bonding

#### Changes in Control Systems/ Elements:

- programming change
- controller action
- control valve trim/sizing
- instrument/transmitter
- sensing element
- graphically displayed information
- system response to alarm

#### Changes in Environmental Conditions:

- discharge air quality
- discharge water quality
- solid waste



# 2019 MANAGEMENT OF CHANGE REQUEST FORM

Name of Person or Group Requesting Change: Seth Messick Date: 3-26-19

Summary Description of Change:

PCB Voltage Regulator and switch assembly is being replaced with a single, radio-shack 5V spdt relay.  
printed circuit board. AMB 4-3-19

Reason(s) for Change:

The PCB Voltage Regulator and Switch assembly was found to be more complicated than necessary

Change is:  permanent  temporary Duration of change: \_\_\_\_\_

Signature of Requestor: Seth Messick

- |                       |                                     |  |
|-----------------------|-------------------------------------|--|
| Attachment checklist: | Yes                                 | N/A  |
|                       | <input type="checkbox"/>            | <input checked="" type="checkbox"/> Updated Process Flow Sheet, if changed   |
|                       | <input type="checkbox"/>            | <input checked="" type="checkbox"/> Current Process Flow Sheet               |
|                       | <input checked="" type="checkbox"/> | <input type="checkbox"/> Updated JSA pages, if changed                       |
|                       | <input checked="" type="checkbox"/> | <input type="checkbox"/> Current JSA pages                                   |
|                       | <input checked="" type="checkbox"/> | <input type="checkbox"/> Updated Engineering documentation pages, if changed |
|                       | <input checked="" type="checkbox"/> | <input type="checkbox"/> Current Engineering documentation pages             |
|                       | <input checked="" type="checkbox"/> | <input type="checkbox"/> Safety Evaluation Checklist (req'd. - see below)    |

## PROCESS CHANGE REQUEST APPROVAL FORM

**Type of Change:**  Major - Requires review by entire team and faculty adviser  
 Minor - Requires review by team only

**Description of Change as Approved:**

See line 16 of equipment list. Change approved as submitted.

**Approved Duration of Change:** Permanent

**Signatures of Approval**

Faculty Adviser:	<u>Dan M. Bough</u>	Date: <u>4-3-19</u>
Review Team Member:	<u>Zeynep C. C. II</u>	Date: <u>4/3/19</u>
Review Team Member:	_____	Date: _____
Review Team Member:	_____	Date: _____
Review Team Member:	_____	Date: _____
Review Team Member:	_____	Date: _____
Review Team Member:	_____	Date: _____

Attach minutes and pertinent notes from review team meetings and place in permanent file.

## Management of Change Request Form

### SAFETY EVALUATION CHECKLIST

Complete this safety evaluation checklist, noting any conditions that apply to the proposed change. Attach a more detailed description of the change, if necessary, along with all supporting materials.

#### Changes in Process Conditions/Materials:

- temperature
- pressure
- flow
- level
- composition
- chemical
- toxicity
- flash point
- reaction conditions
- biohazard
- use of regulated materials
- use of lasers/ change in class of lasers

#### Changes in Operating Conditions/ Procedures:

- startup
- normal operations
- abnormal operations
- shut down
- emergency shut down
- maintenance procedures
- lock-out
- tagging

#### Changes in Process Equipment:

- size or capacity
- materials of construction
- seals and gasket materials
- piping/ valving
- electrical system
- max./min. working pressure
- max./min. working temperature
- equipment guarding
- thermal insulation/insulation coverings
- filters
- support structures

#### Changes in Facilities:

- ventilation
- lighting
- utility services
- building modifications/renovations

#### Changes in Safety Equipment:

- containment
- guarding
- fire protection
- fire detection
- safety equipment location
- safety equipment type
- personal protective equipment
- grounding/bonding

#### Changes in Control Systems/ Elements:

- programming change
- controller action
- control valve trim/sizing
- instrument/transmitter
- sensing element
- graphically displayed information
- system response to alarm

#### Changes in Environmental Conditions:

- discharge air quality
- discharge water quality
- solid waste



## Equipment List

Please list every piece of equipment on the car. Please include all manufacturer's specification documents or specifications for custom-built components in the EDP Supplement document.

Number	Equipment	Manufacturer	Operating Limits: Temperature	Operating Limits: Pressure	Incompatible Materials?
1.	Aluminum Chassis	Previous UW Chem E Car Team	< 1220 °F	N/A	None
2.	K'nex axles, tires, and motor	K'nex corporation	Not listed	N/A	None
3.	22 gauge Appliance Wire	Carol	-4 °F to 221 °F	N/A	Sparks, H <sub>2</sub> O
4.	Geiger counter	Images Scientific Instruments	Not listed	N/A	Liquids
5.	PLA printed electronics housing	UW Coe Library Makerspace	<145 °F	N/A	None
6.	2x4 Wood Block	Truss Craft	N/A	N/A	Sparks
7.	5 x Horizon PEM Reversible Fuel Cells	Fuel Cell Store	Not listed	Not listed	Not listed
8.	Latex Balloon	Walmart	<130 F	0.15 psig	Not Listed
9.	Gorilla Tape	Gorilla Glue Industries	-40 °F to 120 °F	N/A	None
10.	PVC 3/8" x Tubing	UW Chem Stockroom	< 200 °F	Joints at 1 psig	None
11.	Vacuum Connector Ts	Dorman	Not listed	Not listed	None
12.	Banana Plugs	Cal Test Electronics	Not listed	N/A	Sparks
13.	Lexel Silicon Sealant	Sashco corp	-18°C - 49°C	N/A	Strong oxidizing agents
14.	myRIO 1900	National Instruments	0°C - 40°C	N/A	Liquids
15.	Digilent MXP Bread Board	Digilent	N/A	N/A	Sparks, H <sub>2</sub> O
16.	SPDT Micromini 5VDC Relay	RadioShack Technology Plus	-22 °F to 167 °F	N/A	Sparks, H <sub>2</sub> O
17.	9V Snap Connectors	Keystone Electronics	N/A	N/A	Only compatible with 9V batteries
18.	9V Battery	Duracell 9V Batteries	-4°F to 130°F (-20° C to 54° C)	N/A	Sparks, H <sub>2</sub> O,

Notes  
→  
here





This is the closest I could find to an SDS

## 275-0240 Radio Shack 5-volt relay

---

### Coil voltage

Nominal 5VDC  
Maximum 6.5VDC

### Nominal current:

89.3mA

### Pick-up voltage:

3.5VDC

### Drop-out voltage:

0.25VDC

### Coil resistance:

56 ohms  $\pm$  10%

### Life

Electrical (at rated voltage and current): 100,000 cycles

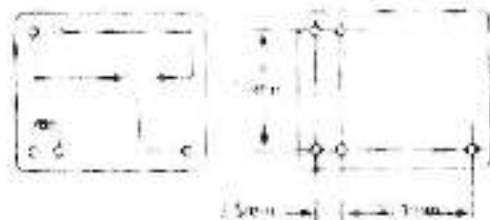
Mechanical (with no load): 10,000,000 cycles

### Operating temperature:

-22° to 167°F  
-30°C to 75°C  
at 70-80% RH



### Bottom View



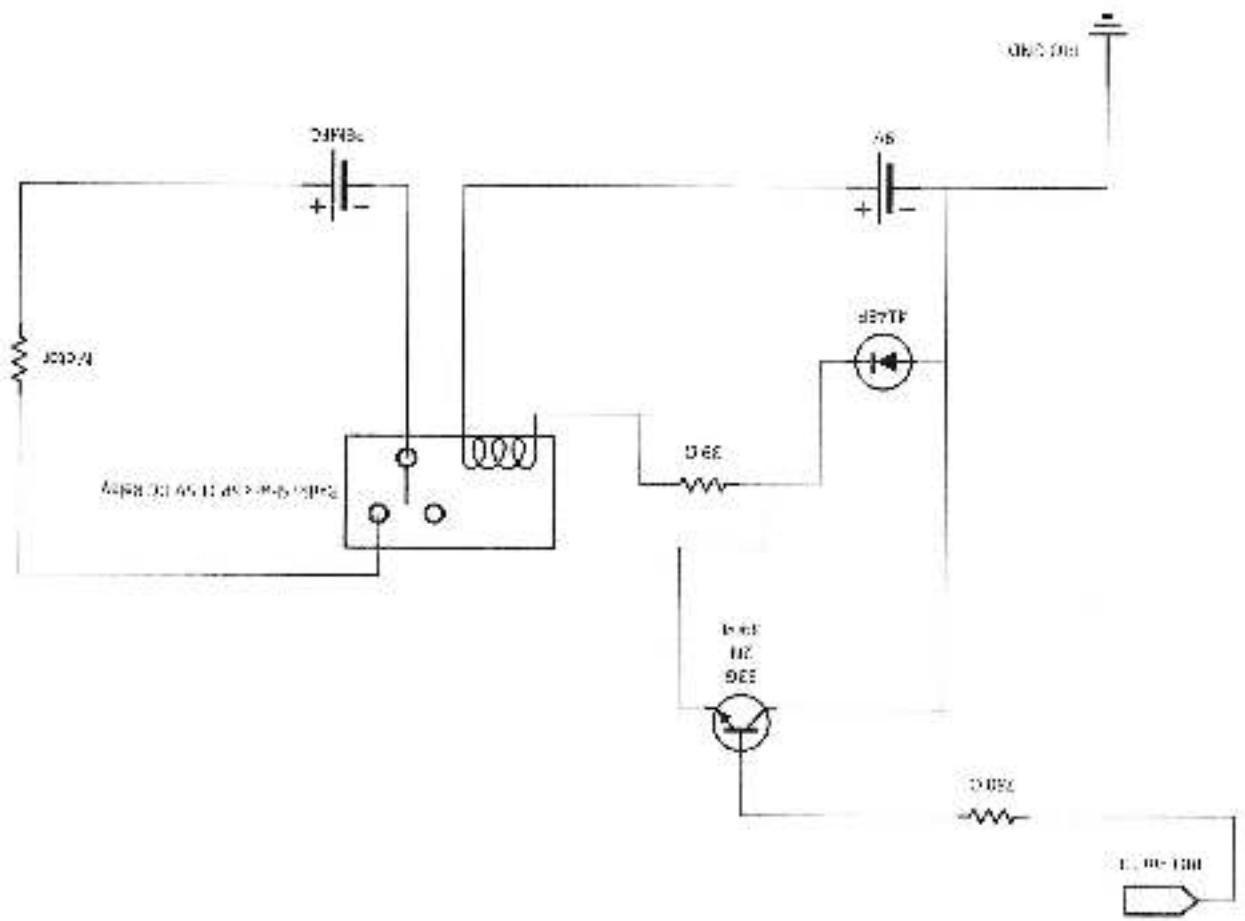
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Retrieved from "https://hyp.org/mw/index.php?title=275-0240\_Radio\_Shack\_5-volt\_relay&oldid=5385"

This page was last edited on 24 February 2006, at 17:56.

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## 2019 MANAGEMENT OF CHANGE REQUEST FORM

Name of Person or Group Requesting Change: \_\_\_\_\_

Chem E-Cnt Unit

Cnd

Date:

\_\_\_\_\_ 03/27/19

Summary Description of Change:

Replacing latex balloons previously used to collect Hydrogen gas with Hydrogen containment vessels manufactured by Fuel Cell Store

Reason(s) for Change:

Fuel Cell Store's Hydrogen Containment vessels deliver more consistent H<sub>2</sub> to PEM Fuel cells than latex balloons.

Change is:  permanent

temporary

Duration of change: \_\_\_\_\_ 03/27/19

Signature of Requestor: *Kenneth Tice*

Attachment checklist:

Yes




N/A




Updated Process Flow Sheet, if changed

Current Process Flow Sheet

Updated JSA pages, if changed

- Current JSA pages
- Updated Engineering documentation pages, if changed
- Current Engineering documentation pages
- Safety Evaluation Checklist (req'd. - see below)

**Management of Change Request Form**

**PROCESS CHANGE REQUEST  
APPROVAL FORM**

**Type of Change:**  Major - Requires review by entire team and faculty adviser  
 Minor - Requires review by team only

**Description of Change as Approved:**

*Line 8 of equipment list, description of procedures - change approved as submitted.*

**Approved Duration of Change:** Permanent

**Signatures of Approval**

Faculty Adviser: *David M. Bogle* Date: 4-3-19

Review Team Member: *Yusef Al Chirif II* Date: 4/3/19

Review Team Member: \_\_\_\_\_ Date: \_\_\_\_\_

Review Team Member: \_\_\_\_\_ Date: \_\_\_\_\_

Review Team Member: \_\_\_\_\_ Date: \_\_\_\_\_

Review Team Member: \_\_\_\_\_ Date: \_\_\_\_\_

Review Team Member: \_\_\_\_\_ Date: \_\_\_\_\_

**Attach minutes and pertinent notes from review team meetings and place in permanent file.**

## Management of Change Request Form

### SAFETY EVALUATION CHECKLIST

Complete this safety evaluation checklist, noting any conditions that apply to the proposed change. Attach a more detailed description of the change, if necessary, along with all supporting materials.

#### Changes in Process Conditions/Materials:

- temperature
- pressure
- flow
- level
- composition
- chemical
- toxicity
- flash point
- reaction conditions
- biohazard
- use of regulated materials
- use of lasers/ change in class of lasers

#### Changes in Operating Conditions/ Procedures:

- startup
- normal operations
- abnormal operations
- shut down
- emergency shut down
- maintenance procedures
- lock-out
- tagging

#### Changes in Process Equipment:

- size or capacity
- materials of construction
- seals and gasket materials
- piping/ valving
- electrical system
- max./min. working pressure
- max./min. working temperature
- equipment guarding
- thermal insulation/insulation coverings
- filters
- support structures

#### Changes in Facilities:

- ventilation
- lighting
- utility services
- building modifications/renovations

#### Changes in Safety Equipment:

- containment
- guarding
- fire protection
- fire detection
- safety equipment location
- safety equipment type
- personal protective equipment
- grounding/bonding

#### Changes in Control Systems/ Elements:

- programming change
- controller action
- control valve trim/sizing
- instrument/transmitter
- sensing element
- graphically displayed information
- system response to alarm

#### Changes in Environmental Conditions:

- discharge air quality
- discharge water quality
- solid waste





**Stopping mechanism:**

A known concentration of Cesium-137 is measured by a Geiger counter tube, which sends electronic pulses to a control unit. The control unit counts and stores the amount of elapsed pulses. Once a pre-specified number of pulses is reached, the control unit triggers a relay switch to cut power to the electric motor. The rate of pulses is controlled by aluminum shields ranging in thickness from 0 to 8.5 mm in increments of 0.5 mm placed between the Cesium-137 and the Geiger tube.

**Hazards inherent in design:**

1. Biological - The use of microorganisms as the power source for the car
2. Radiation - The presence of the radioactive isotope,  $^{137}\text{Cs}$
3. Electrical - The potential for exposed electrical wires to shock operators
4. Hydrogen gas - The potential of explosion from H<sub>2</sub> gas ignited by a spark from the electrical wires

**Safety measures:**

1. Biological - Microorganisms from the rumen of ruminant animals are not considered pathogenic. Regardless, no eating or drinking is allowed in a space where rumen fluids are present and operators are required to wear gloves while handling rumen fluids and/or wash hands with soap afterwards as well as wear safety glasses under standard microbiological lab practices.
2. Radiation - The radiation for the car comes from a 10  $\mu\text{Ci}$   $^{137}\text{Cs}$  source sealed in a plastic shell. This quantity and species of radioactive source is considered exempt from radiation safety measures by the NRC.  $^{137}\text{Cs}$  emits beta- and gamma-radiation but the operator is shielded from all beta-radiation by the plastic shell.  $^{137}\text{Cs}$  emits so little gamma-radiation that it would take 20 years of continuous exposure at 10 cm to the gamma radiation in order to receive the occupational limit set for one year's radiation exposure by the Nuclear Regulatory Commission. As  $^{137}\text{Cs}$  is exempt from radiation safety measures by the NRC, it can be appropriately disposed of in traditional waste receptacles or can be stored in the lab with appropriate labeling in the recycled and reused by design teams at a later date.
3. Electrical - The operator is protected by all electrical components by the appropriate insulation on wires and cases housing circuit boards. All connections are made using screw blocks inside of an insulated case or disc-insulated connectors.
4. Hydrogen gas - The vehicle's power is derived from 40mL of hydrogen (H<sub>2</sub>) gas which is stored in a Hydrogen containment vessel (in the form of an inverted bell vessel within a plastic beaker).

Please list the major design changes for your car, and how it is different from the vehicle your School/Team used for last year's competition (If your school did not compete in the Chem-F-Car Competition in the previous year, you can leave this section blank):

N/A



**Standard / Safe Operating Procedures Page**

Provide step-by-step details for each of the sections shown below. Identify the hazards, the control methods and the personal protective equipment (PPE) applied. Provide adequate detail so that the reviewers of this document will have adequate understanding of your procedure to pass judgment on the safety of your vehicle.

The **Emergency Shutdown** section should have only one or two steps required to stop your vehicle and bring it to a safe state.

The **Start-Up Procedure** section should list all the steps required to prepare your chemicals and vehicle.

The **Run Time Procedure** should describe all steps to operate your vehicle at the crime from starting line.

The **Shutdown Procedure** should describe the steps normally taken to shut down your vehicle at the end of your competitive run.

The **Cleanup / Waste Disposal** section should list all the steps required to clean your vehicle of all chemicals and proper chemical disposal.

Sequence of Steps	Potential Hazards	Procedure to Control Hazard	PPE or Equipment Required
<b>Emergency Shutdown</b> 1. Switch off electric motor using switch on motor body	None	N/A	N/A
<b>Start-up Procedure</b> 1. Add 3.5 g glucose, 0.25 g L-cysteine HCl dissolved in 500 mL rumen fluid to electrolysis cell vessel. 2. Add vinegar to electrolysis cell until pH of cell contents reaches ~ 5.0 3. Seal using anaerobic stoppers 4. Place balloon over airtock to capture hydrogen gas 4. Incubate fuel cell for a minimum of one hour while electrolyzing with a constant potential of 0.8 V. 5. Place <sup>14</sup> Cs source contained in Pyrex beaker into car body 6. Add appropriate number of aluminum shields into holder and place over Pyrex beaker container 7. Place Geiger tube in holder above Pyrex beaker	Biological Radiation Electrical	Absence of pathogens Lab procedure Exempt radiation quantity Pyrex beaker containment, plastic shielding Insulated electrical circuits	Safety glasses Close-toed shoes Long pants

5. Remove hydrogen containment vessel from electrolysis cell, place onto nozzle on car body			
<b>Run Time Procedure</b>			
1. Remove excess aluminum shielding from holder 2. Press button on microcontroller unit to reset counter and close circuit	Radiation	Exempt quantity Pyrex beaker containment	None
<b>Shutdown Procedure</b>			
1. Remove hydrogen containment vessel	Hydrogen gas escaping while Hydrogen containment vessel is capped	Clamp tubing that connects Hydrogen containment vessel to PEM fuel cells before removing from PEM fuel cells	None
<b>Cleanup / Waste Disposal</b>			
1. Place <sup>14</sup> Cs source in lead containment tube and cover with lid 2. Remove anaerobic stoppers from fuel cells and dispose of depleted rumen fluid in an appropriate compost pile/manure pit/biowaste disposal. 3. Disinfect any surfaces that may have been exposed to rumen fluid using bleach	Radiation Biological	Exempt radiation quantity Lead shielding Absence of pathogens Lab procedure	Safety glasses Close-toed shoes Long pants

### Equipment List

Please list every piece of equipment on the car. Please include all manufacturer's specification documents or specifications for custom-built components in the EDP Supplement document.

Number	Equipment	Manufacturer	Operating Limits: Temperature	Operating Limits: Pressure	Incompatible Materials?
1.	Aluminum Chassis	Previous UW Chem E Car Team	< 1220 °F	N/A	None
2.	K'nex axes, tires, and motor	K'nex corporation	Not listed	N/A	None
3.	22 gauge Appliance Wires	Carol	-4 °F to 221 °F	N/A	Sparks, H <sub>2</sub> O
4.	Geiger counter	Images Scientific Instruments	Not listed	N/A	Liquids
5.	PLA printed electronics housing	UW Coe Library Makerspace	<145 °F	N/A	None
6.	2x4 Wood Block	Truss Craft	N/A	N/A	Sparks
7.	5 x Horizon PEM Reversible Fuel Cells	Fuel Cell Store	Not listed	Not listed	Not listed
8.	Hydrogen Containment Vessel, Inverted Bell Vessel	Fuel Cell Store	Not listed	Not listed	Not Listed
9.	Gorilla Tape	Gorilla Glue Industries	-10 °F to 120 °F	N/A	None
10.	PVC 3/8" x Tubing	UW Chem Stockroom	< 200 °F	Joints at 1 psig	None
11.	Vacuum Connector Ts	Domnan	Not listed	Not listed	None
12.	Barbara Plugs	Cal Test Electronics	Not listed	N/A	Sparks
13.	Lexel Silicon Sealant	Sashco corp	-18°C - 49°C	N/A	Strong oxidizing agents
14.	myRIO 1900	National Instruments	0°C - 40°C	N/A	Liquids



[Home](#) » [30 mL Storage Cylinders \(2\)](#)

## 30 mL Storage Cylinders (2)

Brand: Horizon Fuel Cell Technologies

Product Code: 7110307

Price: \$17.00

Qty: 1


ADD TO CART

- OR - [Add to Wish List](#)  
[Add to Compare](#)

Zoom



### RECOMMENDED ACCESSORIES:

 Horizon Silicon Tubing - 5 Feet \$10.00 Qty: 1 [Add to Cart](#)

★ ★ ★ ★ 1 reviews | [Write a review](#)

0

[Description](#)   [Spare Parts](#)   [Reviews \(1\)](#)

These two storage cylinders, one for hydrogen and one for oxygen, can be used to store 30 milliliters (mL) of hydrogen and oxygen to be used to power a Proton Exchange Membrane Fuel Cell (PEMFC) or any other application requiring gasses.

#### Contents Include:

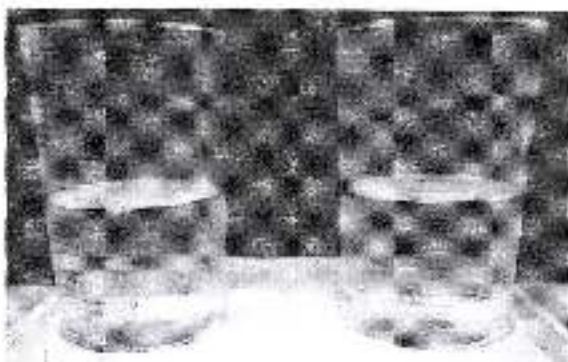
- ✓ 2 x Cylindrical Beakers
- ✓ 2 x Inner Containers

**Need Extra Tubing?** - Horizon's 3mm Inner Diameter Silicon Tubing (<https://fuelcellstore.com/horizon-fuel-cell-silicon-tubing>) is a perfect fit for the 30mL Storage Cylinders.

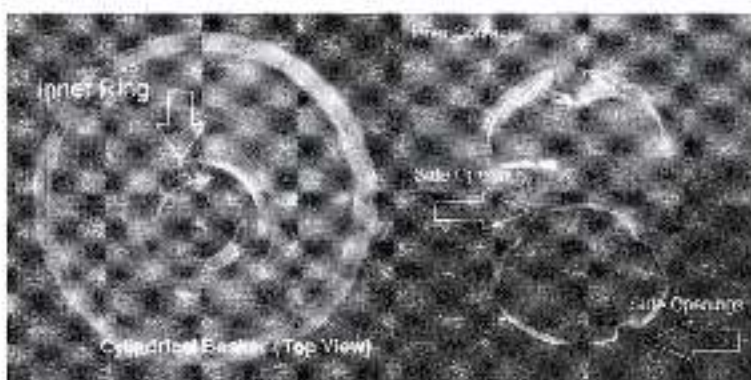
#### How Do They Work?

**Step 1)** Fill the two cylindrical beakers with distilled water until the water level reaches zero.





**Step 2)** Place the two inner containers into the cylindrical beakers (make sure the side openings on the inner container is not blocked by the inner ring on the beakers), the distilled water from the beaker will fill out the inner container at this point.



**Step 3)** Connect two long tubes to the inner container on each of the beakers corresponding to oxygen and hydrogen on the fuel cell. (Make sure there is no air in the inner containers)



#### RELATED PRODUCTS (13)



Horizon Silicon Tubing - 5 Feet

\$12.00

★ ★ ★ ★

Add to Cart



RFC H2/O2/Air

Request a Quote



Mini Water Pump

\$6.00

Add to Cart



Horizon Mini PEM Electrolyzer

\$55.50

★ ★ ★ ★ ★

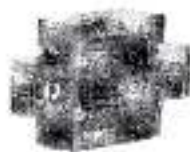
Add to Cart



MINI PEM Fuel Cell - Green

\$52.00

Add to Cart



Horizon Mini PEM Fuel Cell

\$52.00

★ ★ ★ ★ ★

Add to Cart



Electrolyzer Cell 10

\$770.00

Add to Cart



Storage 50

Request a Quote



Solar Hydrogen Education Kit

\$60.25

★ ★ ★ ★ ★

Add to Cart



Electrolyzer Cell 5

\$130.00

Add to Cart



Intelligent Fuel Cell Car Lab

\$55.50

★ ★ ★ ★ ★

Add to Cart



Storage 30

Request a Quote



Horizon Mini PEM  
Reversible Fuel Cell

\$65.00

★★★★★

Add to Cart



## 2019 MANAGEMENT OF CHANGE REQUEST FORM

Name of Person or Group Requesting Change: \_\_\_\_\_ Chem-6-Car. Train  
 Cnd \_\_\_\_\_ Date: \_\_\_\_\_  
 \_\_\_\_\_ 04/01/19

### Summary Description of Change:

Addition of Oxygen gas as a fuel in conjunction with the Hydrogen gas to the PEM fuel cells. Oxygen gas is generated during electrolysis of the PLM reversible cells and is stored in Hydrogen containment vessels.

### Reason(s) for Change:

The addition of Oxygen gas a fuel to PEM fuel cells increases the power production of the fuel cells.

Change is:  permanent  
 temporary Duration of change: \_\_\_\_\_ 04/01/19

Signature of Requestor: Amadee Ture

Attachment checklist:

Yes	N/A
<input type="checkbox"/>	<input type="checkbox"/> Updated Process Flow Sheet, if changed
<input checked="" type="checkbox"/>	<input type="checkbox"/> Current Process Flow Sheet
<input type="checkbox"/>	<input type="checkbox"/> Updated JSA pages, if changed
<input type="checkbox"/>	<input type="checkbox"/> Current JSA pages

- Updated Engineering documentation pages, if changed
- Current Engineering documentation pages
- Safety Evaluation Checklist (req'd. see below)

**Management of Change Request Form**

**PROCESS CHANGE REQUEST  
APPROVAL FORM**

**Type of Change:**     Major    Requires review by entire team and faculty adviser  
 Minor    Requires review by team only

**Description of Change as Approved:**

*Change approved as amended in attachments.*

**Approved Duration of Change:**    Permanent

**Signatures of Approval**

Faculty Adviser:    *David M. Brady*    Date: 4-3-19

Review Team Member:    *John O. Clivato II*    Date: 4/3/19

Review Team Member:    \_\_\_\_\_    Date: \_\_\_\_\_

Review Team Member:    \_\_\_\_\_    Date: \_\_\_\_\_

Review Team Member:    \_\_\_\_\_    Date: \_\_\_\_\_

Review Team Member:    \_\_\_\_\_    Date: \_\_\_\_\_

Review Team Member:    \_\_\_\_\_    Date: \_\_\_\_\_

Review Team Member:    \_\_\_\_\_    Date: \_\_\_\_\_

**Attach minutes and pertinent notes from review team meetings and place in permanent file.**



## Management of Change Request Form

### SAFETY EVALUATION CHECKLIST

Complete this safety evaluation checklist, noting any conditions that apply to the proposed change. Attach a more detailed description of the change, if necessary, along with all supporting materials.

#### Changes in Process Conditions/Materials:

- temperature
- pressure
- flow
- level
- composition
- chemical
- toxicity
- flash point
- reaction conditions
- biohazard
- use of regulated materials
- use of lasers/ change in class of lasers

#### Changes in Operating Conditions/ Procedures:

- startup
- normal operations
- abnormal operations
- shut down
- emergency shut down
- maintenance procedures
- lock-out
- tagging

#### Changes in Process Equipment:

- size or capacity
- materials of construction
- seals and gasket materials
- piping/ valving
- electrical system
- max./min. working pressure
- max./min. working temperature
- equipment guarding
- thermal insulation/insulation coverings
- filters
- support structures

#### Changes in Facilities:

- ventilation
- lighting
- utility services
- building modifications/renovations

#### Changes in Safety Equipment:

- containment
- guarding
- fire protection
- fire detection
- safety equipment location
- safety equipment type
- personal protective equipment
- grounding/bonding

#### Changes in Control Systems/ Elements:

- programming change
- controller action
- control valve trim/sizing
- instrument/transmitter
- sensing element
- graphically displayed information
- system response to alarm

#### Changes in Environmental Conditions:

- discharge air quality
- discharge water quality
- solid waste



### Chemical Hazards and Disposal

Chemical Properties and Hazards for ALL CHEMICALS, including reactants, intermediates and products.

Chemical Name	Physical State (S, L, G)	NFPA Ratings*				Incompatible Chemicals List chemicals present with in the laboratory, and any others that may come in contact.	Flash Point Temp.	Flammability Limits	
		H	F	S	Sp.			LFL	UFL
Bovine Rumen Fluid	L	N/A	N/A	N/A	N/A	None	N/A	N/A	N/A
L-cysteine HCl	S	1	1	1	N/A	None	N/A	N/A	N/A
Glucose	S	1	0	0	N/A	N/A	N/A	N/A	N/A
Cesium-137	S	3	4	3	Radi oact ive	None	N/A	N/A	N/A
Hydrogen gas	G	0	4	0	0	Unknown (CAMEO Chemicals)	N/A	4.0	75.0
Oxygen gas	G	3	0	0	Oxi. prop.	Cellulose-Based Absorbents Expanded Polymeric Absorbents	Not available	Not available	Not available
Carbon Dioxide		N/A	N/A	N/A	N/A	None	N/A	N/A	N/A

NFPA Ratings: H – Health, F – Flammability, S – Stability, Sp. – Special

Chemical Toxicology, Regulation and Disposal: List the same chemicals that appear above, in the same order.

Chemical Name	Toxicology			Hazardous Waste Number	OSHA Regulated?	Personal Protective Equipment Specific to this Chemical
	TWA	PEL	Other			
Bovine Rumen Fluid	N/A	N/A	N/A	N/A	<input type="checkbox"/>	Close-toed shoes, long pants, safety glasses
L-cysteine HCl	N/A	N/A	N/A	N/A	<input type="checkbox"/>	None
Glucose	N/A	N/A	N/A	N/A	<input type="checkbox"/>	None
Cesium-137	N/A	N/A	N/A	N/A	<input type="checkbox"/>	None
Hydrogen Gas	N/A	N/A	N/A	N/A	<input type="checkbox"/>	Cold-insulating gloves, face shield
Oxygen Gas	N/A	N/A	N/A	N/A	<input type="checkbox"/>	None
Carbon Dioxide	N/A	N/A	N/A	N/A	<input type="checkbox"/>	Close-toed shoes, long pants, safety glasses, Cold-insulating gloves

Biohazards: Provide details below on any biological hazards that may occur during the design, development, preparation or completion phases of your case. Please list the biological hazards, the biohazard level, and a description of how these agents will be safely handled.



Some rumen fluid will be the source of our anaerobic digesting bacteria used to power our fuel cell. Microorganisms from the rumen of ruminant animals are not considered pathogenic. Regardless, no eating or drinking is allowed in a space where rumen fluids are present, and operators are required to wear gloves while handling rumen fluids and/or wash hands afterwards, as well as wear safety glasses under standard microbiological practices.

### Hazards Analysis

**Vehicle Primary Hazards Checklist:** Check the box in the left hand column if the hazards listed below exist on the vehicle. Then check the applicable means of control for each hazard.

Hazard (check if present)	Control
<input type="checkbox"/> (a) Pressure	Anything greater than 1 psig. <b>Must meet all requirements below:</b> <input type="checkbox"/> Pressure gauge (must read to 2x max. operating pressure) <input type="checkbox"/> Emergency relief device set to no more than 1.1 times the max. operating pressure. Relief sizing calculations must be provided. <input type="checkbox"/> Emergency relief device in proper location. <input type="checkbox"/> Pressure certification – see Pressure Vessel Testing Protocol <input type="checkbox"/> Proper management system to prevent over or mis-charging. <input type="checkbox"/> All car components exposed to pressure must be certified to operate at that pressure. Provide manufacturer's pressure specifications. <input type="checkbox"/> No PVC, cPVC or polyethylene terephthalate (PETE or PET) plastics in pressure service <b>Must have measurements or calculations to prove maximum operating pressure. Max allowable pressure this year is 500 psig. See ChemE car rules for more details on these requirements.</b>
<input type="checkbox"/> (b) Toxicity	Any chemicals with an NFPA toxicity of 2 or greater <input type="checkbox"/> Doubly contained and handled properly.
<input type="checkbox"/> (c) Flammable	Any chemicals with an NFPA flammability rating of 2 or higher. <input type="checkbox"/> Doubly contained and handled properly
<input type="checkbox"/> (d) Reactive	Any chemicals with an NFPA instability/reactivity rating of 2 or 3. <b>Chemicals with a 4 rating are not allowed.</b> <input type="checkbox"/> Doubly contained and handled properly.
<input type="checkbox"/> (e) Temperature	Any exposed surface greater than 150 deg. F or under 32 deg F. <input type="checkbox"/> Insulation or barrier to prevent contact.
<input checked="" type="checkbox"/> (f) Electrical	Exposed wiring and electrically energized components are ignition, electrocution, and a shorting/fire hazard. Alligator clips and twisted wire connections are not allowed; use binding posts or banana plugs for a more secure connection. <input checked="" type="checkbox"/> Proper electrical insulation and connections provided.
<input type="checkbox"/> (g) Mechanical	Any fast moving parts (meshing gears, belts or chains) that are pinch hazards <input type="checkbox"/> Guards present and adequate.
<input checked="" type="checkbox"/> (h) Oxygen	All components exposed to oxygen. These must be <input checked="" type="checkbox"/> certified for oxygen service. <input checked="" type="checkbox"/> thoroughly cleaned of contaminants as per instructions in rules. <input checked="" type="checkbox"/> not used previously for other types of service.
<input checked="" type="checkbox"/> (i) Biohazards	<input checked="" type="checkbox"/> No biohazards greater than biohazard level 1 either during the design, development, preparation or competition phases of your car.

TC  
4/3/19



**Stopping mechanism:**

A known concentration of Cesium-137 is measured by a Geiger counter tube, which sends electronic pulses to a control unit. The control unit counts and stores the amount of elapsed pulses. Once a pre-specified number of pulses is reached, the control unit triggers a relay switch to cut power to the electric motor. The rate of pulses is controlled by aluminum shields ranging in thickness from 0 to 6.5 mm in increments of 0.5 mm placed between the Cesium-137 and the Geiger tube.

**Hazards inherent in design:**

1. Biological - The use of microorganisms as the power source for the car
2. Radiation - The presence of the radioactive isotope,  $^{137}\text{Cs}$
3. Electrical - The potential for exposed electrical wires to shock operators
4. Hydrogen gas - The potential of exposition from H gas ignited by a spark from the electrical wires

**Safety measures:**

1. Biological - Microorganisms from the rumen of ruminant animals are not considered pathogenic. Regardless, no eating or drinking is allowed in a space where rumen fluids are present and operators are required to wear gloves while handling rumen fluids and/or wash hands with soap afterwards as well as wear safety glasses under standard microbiological lab practices.
2. Radiation - The radiation for the car comes from a  $10\ \mu\text{Ci}\ ^{137}\text{Cs}$  source sealed in a plastic shell. This quantity and species of radioactive source is considered exempt from radiation safety measures by the NRC.  $^{137}\text{Cs}$  emits beta- and gamma-radiation but the operator is shielded from all beta-radiation by the plastic shell.  $^{137}\text{Cs}$  emits so little gamma-radiation that it would take 20 years of continuous exposure at 10 cm to the gamma radiation in order to receive the occupational limit set for one year's radiation exposure by the Nuclear Regulatory Commission. As  $^{137}\text{Cs}$  is exempt from radiation safety measures by the NRC, it can be appropriately disposed of in traditional waste receptacles or can be stored in the lab with appropriate labeling in the recycled and reused by design teams at a later date.
3. Electrical - The operator is protected by all electrical components by the appropriate insulation on wires and cases housing circuit boards. All connections are made using screw blocks inside of an insulated case or disc insulated connectors.
4. Hydrogen gas - The vehicle's power is derived from 40mL of hydrogen ( $\text{H}_2$ ) gas which is stored in a latex balloon.

Please list the major design changes for your car, and how it is different from the vehicle your School/Team used for last year's competition (If your school did not compete in the Chem-E-Car Competition in the previous year, you can leave this section blank):

N/A

5. Oxygen gas. Oxygen gas is stored in containment vessels rated for oxygen service which have never been used for any other compounds.  
TC, 4/3/14







### 2019 MANAGEMENT OF CHANGE REQUEST FORM

Name of Person or Group Requesting Change: Jake Maksin

Date: 31-01-19

Summary Description of Change:

There is no change to the car but a change to the parts list. We are adding a water bottle to the list.

Reason(s) for Change:

This part was not on the parts list.

Change is:  permanent  
 temporary

Duration of change: \_\_\_\_\_

Signature of Requestor: Jake Maksin 4-1-19

- Attachment checklist:
- |                                     |     |   |
|-------------------------------------|-----|---|
| <input type="checkbox"/>            | Yes | <input checked="" type="checkbox"/> Updated Process Flow Sheet, if changed              |
| <input type="checkbox"/>            | N/A | <input checked="" type="checkbox"/> Current Process Flow Sheet                          |
| <input checked="" type="checkbox"/> |     | <input type="checkbox"/> Updated JSA pages, if changed                                  |
| <input type="checkbox"/>            |     | <input checked="" type="checkbox"/> Current JSA pages                                   |
| <input type="checkbox"/>            |     | <input checked="" type="checkbox"/> Updated Engineering documentation pages, if changed |
| <input checked="" type="checkbox"/> |     | <input type="checkbox"/> Current Engineering documentation pages                        |
| <input checked="" type="checkbox"/> |     | <input type="checkbox"/> Safety Evaluation Checklist (req'd. - see below)               |



## Management of Change Request Form

### SAFETY EVALUATION CHECKLIST

Complete this safety evaluation checklist, noting any conditions that apply to the proposed change. Attach a more detailed description of the change, if necessary, along with all supporting materials.

#### Changes in Process Conditions/Materials:

- temperature
- pressure
- flow
- level
- composition
- chemical
- toxicity
- flash point
- reaction conditions
- biohazard
- use of regulated materials
- use of lasers/ change in class of lasers

#### Changes in Operating Conditions/ Procedures:

- startup
- normal operations
- abnormal operations
- shut down
- emergency shut down
- maintenance procedures
- lock-out
- tagging

#### Changes in Process Equipment:

- size or capacity
- materials of construction
- seals and gasket materials
- piping/ valving
- electrical system
- max./min. working pressure
- max./min. working temperature
- equipment guarding
- thermal insulation/insulation coverings
- filters
- support structures

#### Changes in Facilities:

- ventilation
- lighting
- utility services
- building modifications/renovations

#### Changes in Safety Equipment:

- containment
- guarding
- fire protection
- fire detection
- safety equipment location
- safety equipment type
- personal protective equipment
- grounding/bonding

#### Changes in Control Systems/ Elements:

- programming change
- controller action
- control valve trim/sizing
- instrument/transmitter
- sensing element
- graphically displayed information
- system response to alarm

#### Changes in Environmental Conditions:

- discharge air quality
- discharge water quality
- solid waste





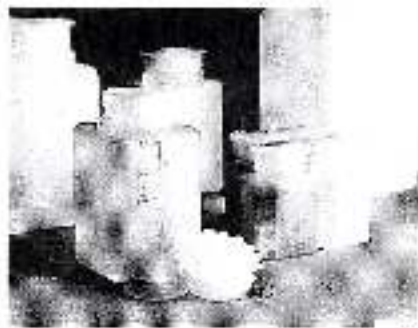
Lab Supplies > Labware > Labware Bottles and Jars > Bottles and Jars > Wide Mouth Rectangular Bottle, Plastic, 500mL, Clear, 6 PK >


[Home](#) [Help](#)

KARTELL

## Wide Mouth Rectangular Bottle, Plastic, 500mL, Clear, 6 PK

SKU # 33N194 | Mfg. Model # 226295-0500 | Catalog Page # 604 | UNSPSC # 41109205



Web Price   
\$27.74 / pkg. of 6



1 Add to cart

Be the first to write a review

Shipping Weight 0.7 lbs.

Country of Origin Italy | Country of Origin is subject to change.

*Note: Product availability is not guaranteed and subject to change. The product will be processed for you when you complete your order. Also*

 How can we improve our product images?

[Compare](#)

### Product Details

This rectangular bottle is designed for storing a variety of substances. HDPE body construction helps to keep out moisture and other contaminants.

### Technical Specs

Item	Bottle	Labware Closure - No Material	Polycarbonate
Labware Capacity - Imperial	16.02	Labware Closure - Material	Polycarbonate
Labware Capacity - Metric	500ml	4. In. Width	No
Material	Wide	Labware Body Color	Clear
Body Shape - Closure	Rectangular	Labware Closure Color	White/Clear
Labware Base - Material	Plastic	Labware Depth - Metric	91mm
Labware Body Material	HDPE	Labware Width - Metric	81mm
Includes Closure	Yes	Special Features	Graduated, Rectangular/Square Bottle Design, Separate Internal Closure Plug For Additional Seal, Hole in Closure For Attachment of Tag
Sanitation - Sterile	Non-Sterile	Quantity - Substances	100-L
Pre-Cleaned	None	Graduation - Range	50 to 500ml
Labware Clarity	Transparent	Labware Height - English	6.4
Labware Closure Type	Screw-On	Labware Weight - Metric	130mm



 [View our improved Technical Specifications?](#)

## Compliance and Restrictions

None

## Alternate Search Terms

[Chemical Bottles \(2458\)](#)

[Plastic Bottles \(596\)](#)

[Rectangular Bottles \(26\)](#)

## Related Products

## Customer Reviews

[Reviews](#)

[Write Reviews](#)

### Product Reviews Disclaimer:

Chicago is neither responsible for nor does it endorse any content or any product shown or statement provided. Any statements provided constitute the statements of the poster and are not the statements of Chicago. The statements posted by Chicago employees will be Chicago's employee's views and not the views of such employees and do not constitute a statement of Chicago. Chicago makes no representation as to the accuracy, completeness, timeliness, availability, or quality of any product or service or any statements provided. Chicago does not warrant the accuracy, completeness, timeliness, availability, or quality of any product or service or any statements provided by employees with the Chicago employee badge and is not liable for any losses, injuries or damages which may result from any such product or service. Any statements or statements provided are provided in a confidential or non-confidential manner.



### Equipment List

Please list every piece of equipment on the car. Please include all manufacturer's specification documents or specifications for custom-built components in the EDP Supplement document.

Number	Equipment	Manufacturer	Operating Limits: Temperature	Operating Limits: Pressure	Incompatible Materials?
1.	Aluminum Chassis	Previous UW Chem E Car Team	< 1220 °F	N/A	None
2.	K'nex axles, tires, and motor	K'nex corporation	Not listed	N/A	None
3.	22 gauge Appliance Wire	Card	-4 °F to 221 °F	N/A	Sparks, H <sub>2</sub> O
4.	Geiger counter	Images Scientific Instruments	Not listed	N/A	Liquids
5.	PI A primed electronics housing	UW Coe Library Makerspace	< 145 °F	N/A	None
6.	2x4 Wood Block	Truss Craft	N/A	N/A	Sparks
7.	5 x Horizon PEM Reversible Fuel Cells	Fuel Cell Store	Not listed	Not listed	Not listed
8.	Hydrogen Containment Vessel Inverted Bell Vessel	Fuel Cell Store	Not listed	Not listed	Not Listed
9.	Gorilla Tape	Gorilla Glue Industries	-40 °F to 120 °F	N/A	None
10.	PVC 3/8" x Tubing	UW Chem Stockroom	< 200 °F	Joints at 1.0 psig	None
11.	Vacuum Connector Ts	Dorman	Not listed	Not listed	None
12.	Banana Plugs	Ca Test Electronics	Not listed	N/A	Sparks
13.	Lowel Silicon Sealant	Sashco corp	-18°C -49°C	N/A	Strong oxidizing agents
14.	myRIO 1900	National Instruments	0°C -40°C	N/A	Liquids

15.	Digilent MXP Bread Board	Digilent	N/A	N/A	Sparks, H <sub>2</sub> O
16.	PCB Voltage Regulator and Switch Assembly	LW Electronics Shop	<115 °F	N/A	Sparks, H <sub>2</sub> O
17.	9V Snap Connectors	Keystone Electronics	N/A	N/A	Only compatible with 9V batteries
18.	9V Battery	Duracell 9V Batteries	4°F to 150°F (-20° C to 54° C)	N/A	Sparks, H <sub>2</sub> O
19.	Lead Solder Stripping tube	Cardinal Heat	0°C - 140 °C	N/A	Liquids
20.	Aluminum Shield		<4,478 °C	N/A	None
21.	Camera	Walman	N/A	N/A	Sparks
22.	Snaps	K-Knife Company	N/A	N/A	None
23.	200 mL Pyrex Beaker no. 1040	Corning	<190 °C	N/A	None
<del>23</del>	Water Bottle	Granger	115-135 °C	N/A	N/A

24. *Tom B. 4-3-19*



### 2019 MANAGEMENT OF CHANGE REQUEST FORM

Name of Person or Group Requesting Change: Andrew Halverton Date: 4/2/19

Summary Description of Change: The lead containment tube originally containing the Cs was replaced with a Pyrex beaker of comparable size.

Reason(s) for Change: The change was made to make the car lighter and thus be able to move better.

Change is:  permanent  temporary Duration of change: \_\_\_\_\_

Signature of Requestor: *Andrew Halverton*

Attachment checklist:	Yes	N/A
	<input checked="" type="checkbox"/>	Updated Process Flow Sheet, if changed
	<input checked="" type="checkbox"/>	Current Process Flow Sheet
	<input checked="" type="checkbox"/>	Updated JSA pages, if changed
	<input checked="" type="checkbox"/>	Current JSA pages
	<input checked="" type="checkbox"/>	Updated Engineering documentation pages, if changed
	<input checked="" type="checkbox"/>	Current Engineering documentation pages
	<input checked="" type="checkbox"/>	Safety Evaluation Checklist (req'd. -- see below)



## PROCESS CHANGE REQUEST APPROVAL FORM

**Type of Change:**     Major – Requires review by entire team and faculty adviser  
                               Minor – Requires review by team only

**Description of Change as Approved:**

*Approved as amended. See subsequent pages.*

**Approved Duration of Change:**    Permanent

**Signatures of Approval**

Faculty Adviser:	<u><i>William Boyler</i></u>	Date: <u>4-3-19</u>
Review Team Member:	<u><i>Lee A. Christy</i></u>	Date: <u>4/3/19</u>
Review Team Member:	_____	Date: _____
Review Team Member:	_____	Date: _____
Review Team Member:	_____	Date: _____
Review Team Member:	_____	Date: _____
Review Team Member:	_____	Date: _____

**Attach minutes and pertinent notes from review team meetings and place in permanent file.**

## Management of Change Request Form

### SAFETY EVALUATION CHECKLIST

Complete this safety evaluation checklist, noting any conditions that apply to the proposed change. Attach a more detailed description of the change, if necessary, along with all supporting materials.

#### Changes in Process Conditions/Materials:

- temperature
- pressure
- flow
- level
- composition
- chemical
- toxicity
- flash point
- reaction conditions
- biohazard
- use of regulated materials
- use of lasers/ change in class of lasers

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#### Changes in Safety Equipment:

- containment
- guarding
- fire protection
- fire detection
- safety equipment location
- safety equipment type
- personal protective equipment
- grounding/bonding

#### Changes in Control Systems/ Elements:

- programming change
- controller action
- control valve trim/sizing
- instrument/transmitter
- sensing element
- graphically displayed information
- system response to alarm

#### Changes in Environmental Conditions:

- discharge air quality
- discharge water quality
- solid waste



**Corning Incorporated  
Life Sciences**

Registered  
ISO 9001:2008

## Product Description

**Catalog Number:** 1060-200

**Product Description:** PYREX® Beaker, Berzelius, Tall Form, with Spout, Single Scale, 200 mL

**Component Materials:**

Type I Class A - Low-Expansion Borosilicate Glass, per ASTM E438 (Standard Specification for Glasses in Laboratory Apparatus)

**Attributes:**

ASTM Reference - E960 Specification for Laboratory Glass Beakers  
Capacity - 200 mL ±10 mL at any mark (5% of full capacity)  
Product Dimensions - 56 mm Body OD x 102 mm High

**Autoclaving:**

This product will withstand repeated standard autoclave cycles of 121°C at 15 psi for 15 minutes.

**Heating / Cooling:**

This product is designed for heating by hot plate, flame, oven, microwave or heating mantles. In normal service it can be heated many times to 230°C. It can be heated one time to 490°C in extreme service.

This product can be cooled to -230°C. DO NOT plunge product directly into a liquid coolant. Place the product in the vapor phase of the liquified gasses for slow cooling prior to immersion in the coolant.

**Vacuum / Pressure:**

This product is not designed for and is not rated for vacuum or pressure applications.

**Sterilization:**

Shipped Not Sterile

**TSE/BSE:**

Materials of animal origin are not used in the manufacture of this product.

**Lot Number Designation:**

Each production lot is uniquely identified with an 8 digit lot number as follows: First 3 digits - Julian date, start of manufacturing; Next 2 digits - Year of manufacture; Last 3 digits - Batch identification.

**Revision Date:**

06 MAR 2013

Rev No: 1



# Material Safety Data Sheet

Material Name: Glass Code 7740

ID: C-021

## \*\*\* Section 1 - Chemical Product and Company Identification \*\*\*

**Chemical Name:** NA

**Product Use:** Use in manufacture of glass articles

**Synonyms:** GC-7740

**Manufacturer Information**

Corning Incorporated

Phone: (607) 974-7661

HP-ME-02-48

Corning, NY 14831

Emergency # CHEMTREC: (800) 424-9300

## \*\*\* Section 2 - Composition / Information on Ingredients \*\*\*

CAS#	Component	Percent
65997-17-1	Glass, oxide, chemicals	100

### Component Related Regulatory Information

This product may be regulated, have exposure limits or other information identified as the following: Nuisance particulates.

### Component Information/Information on Non-Hazardous Components

Glass is a solid material produced by combining various raw materials (e.g. oxides, carbonates, etc.), melting these components together, and cooling to a non-crystalline solid having its own unique properties.

Processing of this article may produce dusts or fumes which are considered hazardous under 29 CFR 1910.1200 (Hazard Communication).

## \*\*\* Section 3 - Hazards Identification \*\*\*

### Emergency Overview

This is a non-combustible, non-reactive solid material. It is supplied in the form of glass sheets or powder. Use methods suitable to fight surrounding fire. Exposure to glass powder or dusts may be irritating to eyes, nose, and throat. At very high exposure levels the dust may have an effect on the lungs.

### Hazard Statements

Dust or powder may be irritating to the eyes, skin, respiratory system and gastrointestinal tract.

### Potential Health Effects: Eyes

Dust or powder may irritate eye tissue. Symptoms can include irritation, redness, scratching of the cornea, and tearing. Rubbing may cause abrasion of cornea.

### Potential Health Effects: Skin

No components in this product are known to be absorbed through the skin. Dust or powder may irritate the skin. Mechanical rubbing may increase skin irritation.

### Potential Health Effects: Ingestion

May cause temporary irritation of the throat, stomach, and gastrointestinal tract.

### Potential Health Effects: Inhalation

Dusts of this product may cause irritation of the nose, throat, and respiratory tract. When inhaled in very large amounts, damage to the lung can occur.

**HMIS Ratings: Health: 0 Fire: 0 Reactivity: 0 PERS. PROT.:** gloves/glasses

**Hazard Scale:** 0 - Minimal 1 - Slight 2 - Moderate 3 - Serious 4 - Severe \* - Chronic hazard

## \*\*\* Section 4 - First Aid Measures \*\*\*

### First Aid: Eyes

Eye injuries from glass particles should be treated by a physician immediately.

### First Aid: Skin

Cuts or abrasions should be treated promptly with thorough cleansing of the affected area.

### First Aid: Ingestion

Seek medical attention if material is ingested.

### First Aid: Inhalation

Move person to non-contaminated air. Call a physician if symptoms persist.



# Material Safety Data Sheet

Material Name: Glass Code 7740

ID: C-021

## First Aid: Notes to Physician

None.

### \*\*\* Section 5 - Fire Fighting Measures \*\*\*

Flash Point: Not applicable

Upper Flammable Limit (UFL): Not applicable

Auto Ignition: Not applicable

Rate of Burning: Not applicable

Method Used: Not applicable

Lower Flammable Limit (LFL): Not applicable

Flammability Classification: Will not burn

#### General Fire Hazards

This material will not burn.

#### Hazardous Combustion Products

Material will begin softening at about 700° C, will proceed to a liquid and will form irritating and toxic gaseous metallic oxides at extremely high temperatures.

#### Extinguishing Media

Use methods for the surrounding fire.

#### Fire Fighting Equipment/Instructions

Wear full protective clothing, including helmet, self-contained positive pressure or pressure demand breathing apparatus, protective clothing and face mask.

NFPA Ratings: Health: 0 Fire: 0 Reactivity: 0

Hazard Scale: 0 - Minimal 1 - Slight 2 - Moderate 3 - Serious 4 - Severe

### \*\*\* Section 6 - Accidental Release Measures \*\*\*

#### Containment Procedures

Avoid creating dusts.

#### Clean-Up Procedures

Wear appropriate protective equipment and clothing during clean-up. Collect spill using a vacuum cleaner with a HEPA filter. Place in a closed container.

#### Evacuation Procedures

None necessary.

#### Special Procedures

Regulations vary. Consult local authorities before disposal. Glass products may be recycled.

### \*\*\* Section 7 - Handling and Storage \*\*\*

#### Handling Procedures

Do not inhale dusts. Avoid generation of airborne dusts. Avoid contact with skin and eyes. Wash thoroughly after handling.

#### Storage Procedures

Store in a dry area.

### \*\*\* Section 8 - Exposure Controls / Personal Protection \*\*\*

#### Exposure Guidelines

##### A: General Product Information

The OSHA air contaminants exposure limits (PELs) are those provided in the 1989 update to 29 CFR 1910.1000. These limits were vacated by OSHA and may not be enforceable. Observe an exposure limit of 15 mg/m<sup>3</sup> (total dust) and 5 mg/m<sup>3</sup> (respirable fraction) for particulate not otherwise classified (PNOCs).

# Material Safety Data Sheet

Material Name: Glass Code 7740

ID: C-021

## B: Component Exposure Limits

### Glass, oxide, chemicals (65997-17-3)

- ACGIH: 10 mg/m<sup>3</sup> TWA (inhalable fraction, particulate matter containing no asbestos and <1% crystalline silica); 3 mg/m<sup>3</sup> TWA (respirable fraction, particulate matter containing no asbestos and <1% crystalline silica) (related to Particulates not otherwise specified (PNOS))
- OSHA (Final): 15 mg/m<sup>3</sup> TWA (total dust); 5 mg/m<sup>3</sup> TWA (respirable fraction) (related to Particulates not otherwise regulated)
- OSHA (Vacated): 15 mg/m<sup>3</sup> TWA (total dust); 5 mg/m<sup>3</sup> TWA (respirable fraction) (related to Particulates not otherwise regulated)

## Engineering Controls

If material is ground, cut, or used in any operation which may generate dusts, use appropriate local exhaust ventilation to keep exposures below the recommended exposure limits.

## PERSONAL PROTECTIVE EQUIPMENT

### Personal Protective Equipment: Eyes/Face

Wear safety glasses with side shields.

### Personal Protective Equipment: Skin

Wear leather or other appropriate work gloves, if necessary for type of operation. The use of coveralls is recommended.

### Personal Protective Equipment: Respiratory

Not normally needed. If permissible levels are exceeded, use NIOSH approved dust respirator.

### Personal Protective Equipment: General

Use good hygiene practices when handling this material including changing and laundering work clothing after use.

## \*\*\* Section 9 - Physical & Chemical Properties \*\*\*

<b>Appearance:</b>	Clear	<b>Odor:</b>	Odorless
<b>Physical State:</b>	Solid (glass or particulate)	<b>pH:</b>	Not applicable
<b>Vapor Pressure:</b>	Not applicable	<b>Vapor Density:</b>	Not applicable
<b>Boiling Point:</b>	Not applicable	<b>Melting Point:</b>	Not applicable
<b>Solubility (H<sub>2</sub>O):</b>	Not applicable	<b>Specific Gravity:</b>	2.23 gm/cm <sup>3</sup>
<b>Freezing Point:</b>	Not applicable	<b>Particle Size:</b>	Not applicable
<b>Softening Point:</b>	821 deg C	<b>Evaporation Rate:</b>	Not applicable
<b>Viscosity:</b>	Not applicable	<b>Bulk Density:</b>	Not applicable
<b>Percent Volatile:</b>	Not applicable	<b>Molecular Weight:</b>	Not applicable

## Physical Properties: Additional Information

No information available.

## \*\*\* Section 10 - Chemical Stability & Reactivity Information \*\*\*

### Chemical Stability

Stable.

### Chemical Stability: Conditions to Avoid

None known.

### Incompatibility

None known.

### Hazardous Decomposition

At very high temperatures, irritating and toxic gaseous metallic oxides can be formed.

### Hazardous Polymerization

Will not occur.

## \*\*\* Section 11 - Toxicological Information \*\*\*

## Acute Toxicity

### A: General Product Information

Dusts may cause mechanical irritation to eyes and skin. Ingestion may cause transient irritation of throat, stomach, and gastrointestinal tract. Inhalation may cause coughing, nose and throat irritation, and sneezing. Higher exposures may cause difficulty breathing, congestion, and chest tightness.



# Material Safety Data Sheet

Material Name: Glass Code 7740

ID: C-021

## B: Component Analysis - LD50/LC50

No LD50/LC50's are available for this product's components.

## Carcinogenicity

### A: General Product Information

No information available.

### B: Component Carcinogenicity

None of this product's components are listed by ACGIH, IARC, OSHA, NIOSH, or NTP.

## Epidemiology

No information available.

## Neurotoxicity

No information available.

## Mutagenicity

No information available.

## Teratogenicity

No information available.

## Other Toxicological Information

Under normal conditions of use for glass products, the likelihood of inhaling or ingesting amounts necessary for these effects to occur is very small.

## \*\*\* Section 12 - Ecological Information \*\*\*

## Ecotoxicity

### A: General Product Information

No information available.

### B: Component Analysis - Ecotoxicity - Aquatic Toxicity

No ecotoxicity data are available for this product's components.

## Environmental Fate

No information available.

## \*\*\* Section 13 - Disposal Considerations \*\*\*

## US EPA Waste Number & Descriptions

### A: General Product Information

No information available.

### B: Component Waste Numbers

No EPA Waste Numbers are applicable for this product's components.

## Disposal Instructions

You must test your waste using methods described in 40 CFR Part 261 to determine if it meets these or other applicable definitions of hazardous wastes. Waste must be handled in accordance with all applicable regulations. Glass products may be recycled.

## \*\*\* Section 14 - Transportation Information \*\*\*

## US DOT Information

Shipping Name: Not regulated as a hazardous material

UN/NA #: Not classified Hazard Class: Not classified Packing Group: Not classified

Required Label(s): None

Additional Info: None

## International Transportation Regulations

This product is not regulated as a hazardous material by the United States (DOT) or Canadian (TDG) transportation regulations.

## \*\*\* Section 15 - Regulatory Information \*\*\*

## US Federal Regulations

### A: General Product Information

This product contains metal(s), which as dusts, fumes or particulates, is subject to the reporting requirements of Section 313 of SARA and its associated regulations. If the physical form and usage meets the definition of an article, no reporting is necessary. All components are on the U.S. EPA TSCA Inventory List.

# Material Safety Data Sheet

Material Name: Glass Code 7740

ID: C-021

## B: Component Analysis

None of this products components are listed under SARA Section 302 (40 CFR 355 Appendix A), SARA Section 313 (40 CFR 372.65), or CERCLA (40 CFR 302.4).

## State Regulations

### A: General Product Information

Other state regulations may apply. Check individual state requirements.

### B: Component Analysis - State

The following components appear on one or more of the following state hazardous substances lists:

Component	CAS	CA	FL	MA	MN	NJ	PA
Glass, oxide, chemicals	65997-17-3	No	No	No	Yes	No	No

## Other Regulations

### A: General Product Information

None identified.

### B: Component Analysis - Inventory

Component	CAS#	TSCA	DSL	EINECS
Glass, oxide, chemicals	65997-17-3	Yes	Yes	Yes

### C: Component Analysis - WHMIS IDL

No components are listed in the WHMIS IDL.

## \*\*\* Section 16 - Other Information \*\*\*

### Other Information

Reasonable care has been taken in the preparation of this information, but Corning makes no warranty of merchantability or any other warranty, expressed or implied, with respect to this information. Corning makes no representations and assumes no liability for any direct, incidental or consequential damages resulting from its use.

Revision information: Version 2.0000, 06-NOV-2002;

Sections 1,2,3,4,5, 6,7,8,9,10,11,12,15,16

were revised due to formulation/regulatory updates.

Previous issue: Version 1.0000, 13-JUN-1997

### Key/Legend

ACGIH = American Conference of Governmental Industrial Hygienists; CAS = Chemical Abstracts Service; CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act; CFR = Code of Federal Regulations; CFR = Controlled Products Regulations; DOT = Department of Transportation; DSL = Domestic Substances List; EINECS = European Inventory of Existing Commercial Chemical Substances; EPA = Environmental Protection Agency; IARC = International Agency for Research on Cancer; IATA = International Air Transport Association; mg/Kg = milligrams per Kilogram; mg/l = milligrams per Liter; mg/m<sup>3</sup> = milligrams per Cubic Meter; MSHA = Mine Safety and Health Administration; NA = Not Applicable or Not Available; NIOSH = National Institute for Occupational Safety and Health; NJTSR = New Jersey Trade Secret Registry; NTP = National Toxicology Program; OSHA = Occupational Safety and Health Administration; SARA = Superfund Amendments and Reauthorization Act; TIGI = Transport Dangerous Goods; TSCA = Toxic Substances Control Act; WHMIS = Workplace Hazardous Materials Information System.

This is the end of MSDS # C-021





### Hazards Analysis

**Additional Fabrication & Operation Hazard Detail Check List:** Check all hazards that are likely to be encountered during your Chem-Car construction and operation. List the major source(s) of the hazard and describe how the hazard(s) will be controlled. If both construction and hazard columns are checked in an individual row, then the hazards should be identified separately for both the construction and operation.

Hazard	Present During		Control Method(s) <sup>1</sup>	PPE Required <sup>1</sup>
	Construction?	Operation?		
Pressure	<input checked="" type="checkbox"/>	<input type="checkbox"/>	None	Safety glasses, closed-toe shoes, long pants, Cold-Insulating gloves for the CO <sub>2</sub> cartridge
Toxicity	<input type="checkbox"/>	<input type="checkbox"/>		
Flammability	<input type="checkbox"/>	<input type="checkbox"/>		
Reactivity/Instability	<input type="checkbox"/>	<input type="checkbox"/>		
Hot Surfaces/High Temp > 150 F (65 C)	<input type="checkbox"/>	<input type="checkbox"/>		
Cold Surfaces/Low Temp < 32 F (0 C)	<input type="checkbox"/>	<input type="checkbox"/>		
Electrical	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Insulation	None
Arc welding	<input type="checkbox"/>	<input type="checkbox"/>		
Gas welding	<input type="checkbox"/>	<input type="checkbox"/>		
Lathe	<input type="checkbox"/>	<input type="checkbox"/>		
Milling machine	<input type="checkbox"/>	<input type="checkbox"/>		
Handheld power tools	<input checked="" type="checkbox"/>	<input type="checkbox"/>	None	Safety glasses, closed-toe shoes, long pants
Drill press	<input type="checkbox"/>	<input type="checkbox"/>		
Other mechanical hazards	<input type="checkbox"/>	<input type="checkbox"/>		
Paint spraying	<input type="checkbox"/>	<input type="checkbox"/>		
Ionizing radiation	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Plastic containment, stored in 200 mL glass beaker	None
Laser radiation	<input type="checkbox"/>	<input type="checkbox"/>		
Asphyxiates	<input type="checkbox"/>	<input type="checkbox"/>		
Open flames	<input type="checkbox"/>	<input type="checkbox"/>		
Potential Spills	<input type="checkbox"/>	<input type="checkbox"/>		
Biohazards:	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Containment, lab practices	Safety glasses, closed-toe shoes, long pants, latex gloves (or hand washing)
Other:	<input type="checkbox"/>	<input type="checkbox"/>		



### Standard / Safe Operating Procedures Page

Provide step-by-step details for each of the sections shown below. Identify the hazards, the control methods and the personal protective equipment (PPE) required. Provide adequate detail so that the reviewers of this document will have adequate understanding of your procedure to pass judgment on the safety of your vehicle.

The **Emergency Shutdown** section should have only one or two steps required to stop your vehicle and bring it to a safe state.

The **Start-Up Procedure** section should list all the steps required to prepare your chemicals and vehicle.

The **Run Time Procedure** should describe all steps to operate your vehicle at the competition starting line.

The **Shutdown Procedure** should describe the steps normally taken to shut down your vehicle at the end of your competitive run.

The **Cleanup / Waste Disposal** section should list all the steps required to clean your vehicle of all chemicals and proper chemical disposal.

Sequence of Steps	Potential Hazards	Procedure to Control Hazard	PPE or Equipment Required
<b>Emergency Shutdown</b>			
1. Switch off electric motor using switch on motor body	None	N/A	N/A
<b>Start-up Procedure</b>			
1. Add 3.5 g glucose, 0.25 g L-cysteine HCl dissolved in 500 mL rumen fluid to electrolysis cell vessel. 2. Add vinegar to electrolysis cell until pH of cell contents reaches ~ 5.0 3. Seal using anaerobic stoppers 4. Place balloon over airlock to capture hydrogen gas 4. Incubate fuel cell for a minimum of one hour while electrolyzing with a constant potential of 0.6 V. 5. Place <sup>137</sup> Cs source contained in Pyrex beaker into car body 6. Add appropriate number of aluminum shields into holder and place over Pyrex beaker container 7. Place Geiger tube in holder above Pyrex beaker	Biological Radiation Electrical	Absence of pathogens Lab procedure Exempt radiation quantity Pyrex beaker containment, plastic shielding Insulated electrical circuits	Safety glasses Close-toed shoes Long pants





8. Remove hydrogen containment vessel from electrolysis cell, place onto nozzle on car body			
<b>Run Time Procedure</b>			
1. Remove excess aluminum shielding from holder 2. Press button on microcontroller unit to reset counter and close circuit	Radiation	Exempt quantity Pyrex beaker containment	None
<b>Shutdown Procedure</b>			
1. Remove hydrogen containment vessel	Hydrogen gas escaping while Hydrogen containment vessel is capped	Clamp tubing that connects Hydrogen containment vessel to PEM fuel cells before removing from PEM fuel cells	None
<b>Cleanup / Waste Disposal</b>			
4. <del>Place <sup>137</sup>Cs source in lead containment tube and cover with lid</del> <i>Am B 9-3-19</i> 2. Remove anaerobic stoppers from fuel cells and dispose of depleted rumen fluid in an appropriate compost pile/manure pit/biowaste disposal. 3. Disinfect any surfaces that may have been exposed to rumen fluid using bleach	Radiation Biological	Exempt radiation quantity <del>Lead shielding</del> <i>Am B 9-3-19</i> Absence of pathogens Lab procedure	Safety glasses Close-toed shoes Long pants





### Equipment List

Please list every piece of equipment on the car. Please include all manufacturer's specification documents or specifications for custom-built components in the EDP Supplement document.

Number	Equipment	Manufacturer	Operating Limits: Temperature	Operating Limits: Pressure	Incompatible Materials?
1.	Aluminum Chassis	Previous UW Chem E Car Team	< 1220 °F	N/A	None
2.	K'nex axles, tires, and motor	K'nex corporation	Not listed	N/A	None
3.	22 gauge Appliance Wire	Carol	-4 °F to 221 °F	N/A	Sparks, H <sub>2</sub> O
4.	Geiger counter	Images Scientific Instruments	Not listed	N/A	Liquids
5.	PLA printed electronics housing	UW Coe Library Makerspace	<145 °F	N/A	None
6.	2x4 Wood Block	Truss Craft	N/A	N/A	Sparks
7.	5 x Horizon PEM Reversible Fuel Cells	Fuel Cell Store	Not listed	Not listed	Not listed
8.	Hydrogen Containment Vessel, Inverted Bell Vessel	Fuel Cell Store	Not listed	Not listed	Not Listed
9.	Gorilla Tape	Gorilla Glue Industries	-40 °F to 120 °F	N/A	None
10.	PVC 3/8" x Tubing	UW Chem Stockroom	< 200 °F	Joints at 1 psig	None
11.	Vacuum Connector Ts	Dorman	Not listed	Not listed	None
12.	Banana Plugs	Cal Test Electronics	Not listed	N/A	Sparks
13.	Lexel Silicon Sealant	Sashco corp	-18°C - 49°C	N/A	Strong oxidizing agents
14.	myRIO 1900	National Instruments	0°C - 40°C	N/A	Liquids



15.	Diligent MXP Bread Board	Diligent	N/A	N/A	Sparks, H <sub>2</sub> O
16.	PCB Voltage Regulator and Switch Assembly	UW Electronics Shop	<145 °F	N/A	Sparks, H <sub>2</sub> O
17.	9V Snap Connectors	Keystone Electronics	N/A	N/A	Only compatible with 9V batteries
18.	9V Battery	Duracell 9V Batteries	-4°F to 130°F (-20° C to 54° C)	N/A	Sparks, H <sub>2</sub> O,
<del>19.</del>	<del>Lead Source Shipping tube</del>	<del>Cardinal Health</del>	<del>0°C - 140 °C</del>	<del>N/A</del>	<del>Liquids</del>
20.	Aluminum Shield		<4,478 °C	N/A	None
21.	Canvas	Walmart	N/A	N/A	Sparks
22.	Snaps	K-Knife Company	N/A	N/A	None
23.	200 mL Pyrex Beaker no. 1040	Corning	<490 °C	N/A	None
24.	Water Bottle	Granger	115-135 °C	N/A	N/A

19 removed Jan B 4-3-19  
 23 added

